# Intel® X48 and X38 Express Chipset

## Thermal and Mechanical Design Guidelines

*— For the and Intel® 82X48 Memory Controller Hub (MCH) and Intel® 82X38 Memory Controller Hub (MCH)*

*March 2008*

*Revision -002*

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# Revision History

| Revision Number | Description | Date |
|---|---|---|
| -001 | • Initial Release | September 2007 |
| -002 | • Added 82X48 MCH<br>• Updated Reference Design Thermal Boundary Conditions<br>• Updated Reference Design Drawings | March 2008 |

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# 1 Introduction

As the complexity of computer systems increases, so do power dissipation requirements. The additional power of next generation systems must be properly dissipated. Heat can be dissipated using improved system cooling, selective use of ducting, and/or passive heatsinks.

The objective of thermal management is to ensure that the temperatures of all components in a system are maintained within functional limits. The functional temperature limit is the range within which the electrical circuits can be expected to meet specified performance requirements. Operation outside the functional limit can degrade system performance, cause logic errors, or cause component and/or system damage. Temperatures exceeding the maximum operating limits may result in irreversible changes in the operating characteristics of the component.

The document is for the following devices:

- Intel® 82X48 MCH
- Intel® 82X38 MCH

This document presents the conditions and requirements to properly design a cooling solution for systems that implement the MCH. Properly designed solutions provide adequate cooling to maintain the MCH case temperature at or below thermal specifications. This is accomplished by providing a low local-ambient temperature, ensuring adequate local airflow, and minimizing the case to local-ambient thermal resistance. By maintaining the MCH case temperature at or below those recommended in this document, a system designer can ensure the proper functionality, performance, and reliability of this component.

***Note:*** Unless otherwise specified, the information in this document applies to all configurations of the Intel® X48 Express Chipset and Intel® X38 Express Chipset.

***Note:*** In this document the use of the term chipset refers to the combination of the MCH and the Intel ICH9. For ICH9 thermal details, refer to the *Intel® I/O Controller Hub 9 (ICH9) Thermal Design Guidelines.*

## 1.1 Terminology

| Term | Description |
|---|---|
| FC-BGA | Flip Chip Ball Grid Array. A package type defined by a plastic substrate where a die is mounted using an underfill C4 (Controlled Collapse Chip Connection) attach style. The primary electrical interface is an array of solder balls attached to the substrate opposite the die. Note that the device arrives at the customer with solder balls attached. |
| Intel® ICH9 | Intel® I/O Controller Hub 9. The chipset component that contains the primary PCI interface, LPC interface, USB, ATA, and/or other legacy functions. |
| MCH | Memory Controller Hub component that contains the processor interface, DRAM controller and PCI Express port. It communicates with the I/O control hub. |
| IHS | Integrated Heat Spreader: a thermally conductive lid integrated into the package to improve heat transfer to a thermal solution through heat spreading. |
| $T_A$ | The local ambient air temperature at the component of interest. The ambient temperature should be measured just upstream of airflow for a passive heatsink or at the fan inlet for an active heatsink. |
| $T_C$ | The case temperature of the MCH component. The measurement is made at the geometric center of the IHS. |
| $T_{C\text{-}MAX}$ | The maximum value of $T_C$. |
| $T_{C\text{-}MIN}$ | The minimum valued of $T_C$. |
| TDP | Thermal Design Power is specified as the maximum sustainable power to be dissipated by the MCH. This is based on extrapolations in both hardware and software technology. Thermal solutions should be designed to TDP. |
| TIM | Thermal Interface Material: thermally conductive material installed between two surfaces to improve heat transfer and reduce interface contact resistance. |
| $\Psi_{CA}$ | Case-to-ambient thermal solution characterization parameter (Psi). A measure of thermal solution performance using total package power. Defined as $(T_C - T_A)$ / Total Package Power. Heat source size should always be specified for $\Psi$ measurements. |

## 1.2 Reference Documents

| Document | Location |
|---|---|
| *Intel® X38 Express Chipset Datasheet* | http://www.intel.com/design/chipsets/datashts/317610.htm |
| *Intel® X48 Express Chipset Datasheet* | http://www.intel.com/design/chipsets/datashts/319122.htm |
| *Intel® I/O Controller Hub 9 (ICH9) Family Thermal Mechanical Design Guide.* | http://www.intel.com/design/chipsets/designex/316974.htm |
| *Intel® Core™2 Duo Processor and Intel® Pentium® Dual Core Thermal and Mechanical Design Guide* | http://www.intel.com/design/processor/designex/317804.htm |
| *Balanced Technology Extended (BTX) Interface Specification* | http://www.formfactors.org |
| *Various System Thermal Design Suggestions* | http://www.formfactors.org |
| *Various Chassis Thermal and Mechanical Design Suggestions* | http://www.formfactors.org |

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# 2 Product Specifications

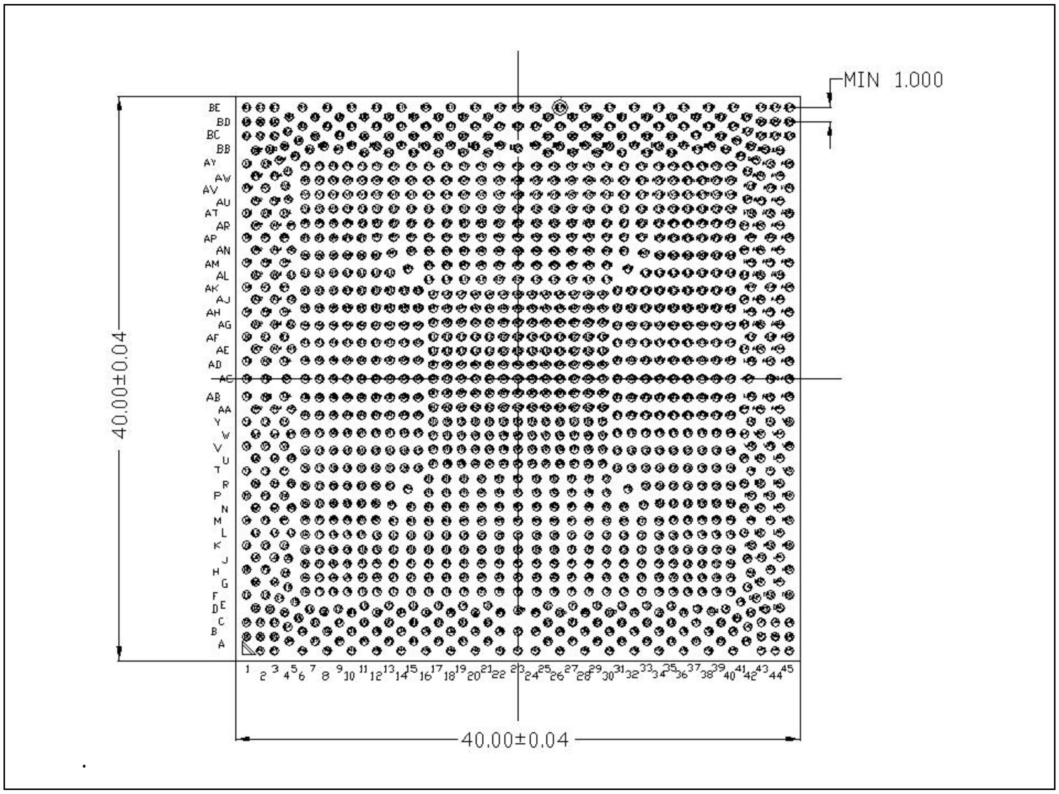
## 2.1 Package Description

The MCH is available in a 40 mm [1.57 in] x 40 mm [1.57 in] Flip Chip Ball Grid Array (FC-BGA) package with an integrated heat spreader (IHS) and 1300 solder balls. A mechanical drawing of the package is shown in Figure 36, Appendix C.

### 2.1.1 Non-Grid Array Package Ball Placement

The MCH package utilizes a “balls anywhere” concept. Minimum ball pitch is 1.0 mm [0.039 in], but ball ordering does not follow a 1.0 mm grid. Board designers should ensure correct ball placement when designing for the non-grid array pattern. For exact XY ball locations relative to the center of the package, refer to the *Intel® X38 Express Chipset Datasheet* and *Intel® X48 Express Chipset Datasheet*. Figure 1 is a view of the MCH non-grid array on a printed circuit board.

**Figure 1. MCH Non-Grid Array**



## 2.2 Package Loading Specifications

Table 1 provides static load specifications for the package. This mechanical maximum load limit should not be exceeded during heatsink assembly, shipping conditions, or standard use conditions. Also, any mechanical system or component testing should not exceed the maximum limit. The package substrate should not be used as a mechanical reference or load-bearing surface for the thermal and mechanical solution.

**Table 1. Package Loading Specifications**

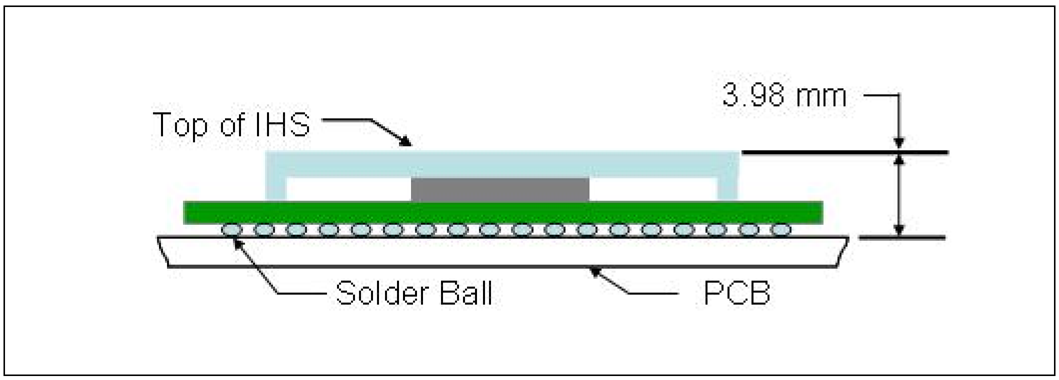
| Parameter | Maximum | Notes |
|---|---|---|
| Static | 15 lbf | 1,2,3 |

**NOTES:**

1. These specifications apply to uniform compressive loading in a direction normal to the package.
2. This is the maximum force that can be applied by a heatsink retention clip.
3. These specifications are based on limited testing for design characterization. Loading limits are for the package only.

To ensure the package static load limit is not exceeded, the designer should understand the post reflow package height. Figure 2 shows the nominal post-reflow package height assumed for calculation of a heatsink clip preload of the reference design. Refer to the package drawing in Appendix C to perform a detailed analysis.

**Figure 2. Package Height**




## 2.3 Thermal Specifications

To ensure proper operation and reliability of the MCH, the case temperature must be at or below the maximum value specified in Table 2. System and component level thermal enhancements are required to dissipate the heat generated and maintain the MCH within specifications. Chapter 3 provides the thermal metrology guidelines for case temperature measurements.

## 2.3.1 Thermal Design Power (TDP)

### 2.3.1.1 Definition

Thermal design power (TDP) is the estimated power dissipation of the MCH based on normal operating conditions including $V_{CC}$ and $T_{C-MAX}$ while executing real worst-case power intensive applications. This value is based on expected worst-case data traffic patterns and usage of the chipset and does not represent a specific software application. TDP attempts to account for expected increases in power due to variation in MCH current consumption due to silicon process variation, processor speed, DRAM capacitive bus loading and temperature. However, since these variations are subject to change, there is no assurance that all applications will not exceed the TDP value.

The system designer must design a thermal solution for the MCH such that it maintains $T_C$ below $T_{C-MAX}$ for a sustained power level equal to TDP. Note that the $T_{C-MAX}$ specification is a requirement for a sustained power level equal to TDP, and that the case temperature must be maintained at temperatures less than $T_{C-MAX}$ when operating at power levels less than TDP. This temperature compliance is to ensure component reliability. The TDP value can be used for thermal design if the thermal protection mechanisms are enabled. The MCH incorporate a hardware-based fail-safe mechanism to keep the product temperature in spec in the event of unusually strenuous usage above the TDP power.

## 2.3.2 TDP Prediction Methodology

### 2.3.2.1 Pre-Silicon

To determine TDP for pre-silicon products in development, it is necessary to make estimates based on analytical models. These models rely on knowledge of the past MCH power dissipation behavior along with knowledge of planned architectural and process changes that may affect TDP. Knowledge of applications available today and their ability to stress various aspects of the MCH is also included in the model. The projection for TDP assumes MCH operation at $T_{C-MAX}$. The TDP estimate also accounts for normal manufacturing process variation.

### 2.3.2.2 Post-Silicon

Once the product silicon is available, post-silicon validation is performed to assess the validity of pre-silicon projections. Testing is performed on both commercially available and synthetic high power applications and power data is compared to pre-silicon estimates. Post-silicon validation may result in a small adjustment to pre-silicon TDP estimates.

### 2.3.3 Thermal Specifications

The data in Table 2 is based on post-silicon measurements for the MCH. The TDP values are based on system configuration with two (2) DIMMs per channel, DDR3 and the FSB operating at the top speed allowed by the chipset with a processor operating at that system bus speed. Intel recommends designing the MCH thermal solution to the highest system bus speed and memory frequency for maximum flexibility and reuse. The MCH packages have poor heat transfer capability into the board and have minimal thermal capability without thermal solutions. Intel requires that system designers plan for an attached heatsink when using the MCH.

**Table 2. Thermal Specifications**

| Component | System Bus Speed | Memory Frequency | Max Idle Power | TDP | $T_{C\text{-}MIN}$ | $T_{C\text{-}MAX}$ | Notes |
|---|---|---|---|---|---|---|---|
| Intel® 82X48 MCH | 1600 MT/s | 1600 MT/s | 15.1 W | 30.5 W | 0 °C | 84 °C | 1,2,3,4,5 |
| Intel® 82X38 MCH | 1333 MT/s | 1333 MT/s | 12.3 W | 26.5 W | 0 °C | 92 °C | 1,2,3,4,5 |

**NOTES:**

1. Thermal specifications assume heatsink is attached.
2. Max Idle power is the worst case idle power in the system booted to Windows* with no background applications running.
3. For the TDP and Max Idle power are measured with DDR3 with 2 channels, 2 DIMMs per channel.
4. Max Idle data is measured for Energy Start when an external graphics card is installed in a system wherein this card must support L1 ASPM.
5. Contact your Intel field sales representative for the latest BIOS revision to enable all power saving features.

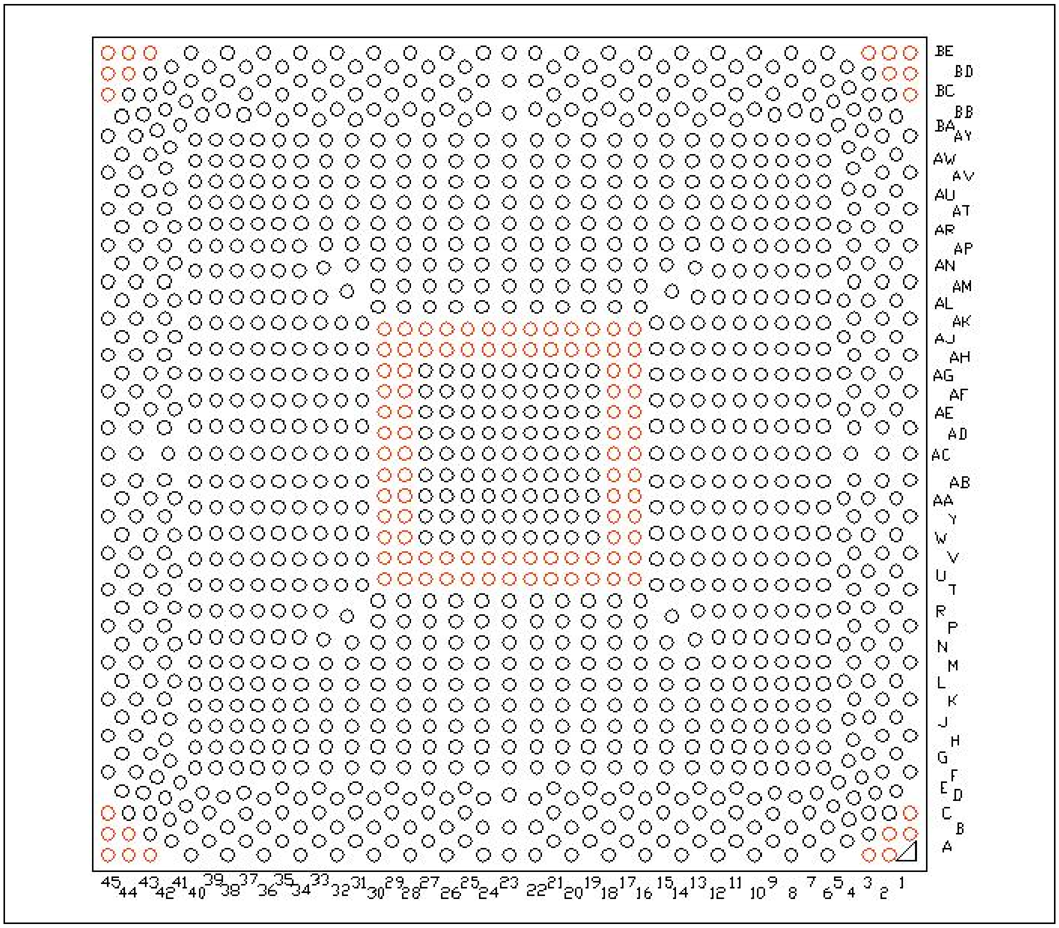
### 2.3.4 $T_{CONTROL}$ Limit

Intel® Quiet System Technology (Intel® QST) can monitor an embedded thermal sensor. The maximum operating limit when monitoring this thermal sensor is $T_{CONTROL}$. For the 82X48 MCH, this value is 86 °C. For the 82X38 MCH, this value is 92 °C. This value should be programmed into the appropriate register of the Intel® QST as the maximum sensor temperature for operation of the MCH.

## 2.4 Non-Critical to Function Solder Balls

Intel has defined selected solder joints of the MCH as non-critical to function (NCTF) when evaluating package solder joints post environmental testing. The MCH signals at NCTF locations are typically redundant ground or non-critical reserved, so the loss of the solder joint continuity at end of life conditions will not affect the overall product functionality. Figure 3 identifies the NCTF solder joints of the MCH package.

**Figure 3. Non-critical to Function Solder Balls**




**NOTE:** Bottom View of Package.

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# 3 Thermal Metrology

The system designer must measure temperatures in order to accurately determine the thermal performance of the system. Intel has established guidelines for proper techniques of measuring MCH component case temperatures.

## 3.1 Case Temperature Measurements

To ensure functionality and reliability of the MCH the $T_C$ must be maintained at or below the maximum temperature listed in Table 2. The surface temperature measured at the geometric center of the IHS corresponds to $T_C$.

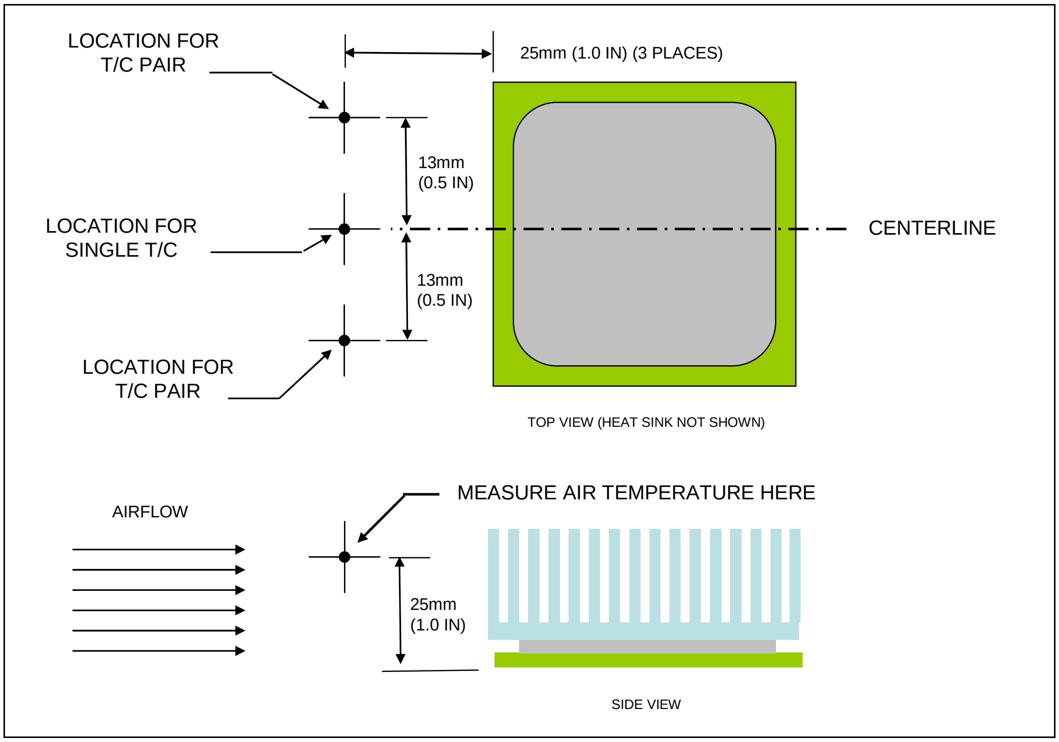
Special care is required when measuring $T_C$ to ensure an accurate temperature measurement. Thermocouples are often used to measure $T_C$. Before any temperature measurements are made, the thermocouples must be calibrated, and the complete measurement system must be routinely checked against known standards. When measuring the temperature of a surface that is at a different temperature from the surrounding local ambient air, errors could be introduced in the measurements. The measurement errors could be caused by poor thermal contact between the junction of the thermocouple and the surface of the integrated heat spreader, heat loss by radiation, convection, by conduction through thermocouple leads, or by contact between the thermocouple cement and the heatsink base.

Appendix A defines a reference procedure for attaching a thermocouple to the IHS of a FCBGA7 chipset package for $T_C$ measurement. This procedure takes into account the specific feature of the FCBGA7 chipset package on the live board for which it is intended.

## 3.2 Airflow Characterization

Figure 4 describes the recommended location for air temperature measurements measured relative to the component. For a more accurate measurement of the average approach air temperature, Intel recommends averaging temperatures recorded from two thermocouples spaced about 25 mm [1.0 in] apart. Locations for both a single thermocouple and a pair of thermocouples are presented.

**Figure 4. Airflow and Temperature Measurement Locations**




Airflow velocity can be measured using sensors that combine air velocity and temperature measurements. Typical airflow sensor technology may include hot wire anemometers. Figure 4 provides guidance for airflow velocity measurement locations which should be the same as used for temperature measurement. These locations are for a typical JEDEC test setup and may not be compatible with chassis layouts due to the proximity of the processor to the MCH. The user may have to adjust the locations for a specific chassis. Be aware that sensors need to be properly aligned to the airflow velocity vector or an inaccurate measurement may result. Consult the vendor's user guide for proper installation. Measurements should be taken with the chassis fully sealed in its operational configuration to achieve a representative airflow profile within the chassis.

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# 4 ATX Reference Thermal Solution

The design strategy for the reference thermal solution for the MCH in ATX platforms differs from previous MCH thermal solutions. The Integrated Heat Spreader (IHS) on the product changed the mechanical response in shock and vibration. Experimental data showed the Preload Wave Solder Heatsink (PWHS) used on previous chipset thermal solutions was not adequately protecting the solder joints on the MCH as it did on previous products.

The reference design described in this document uses a backing plate design that provides measurable improvement in solder joint reliability at the MCH over the PWHS solution.

The thermal interface material and extrusion design requirements are being evaluated for changes necessary to meet the MCH thermal requirements. The keep out zone will have the new requirements of Heatsink mounting hole with the MCH, see Figure 37.

This chapter provides detailed information on operating environment assumptions, heatsink manufacturing, and mechanical reliability requirements for the MCH.

## 4.1 Operating Environment

The operating environment of the MCH will differ depending on system configuration and motherboard layout. This section defines operating environment boundary conditions that are typical for the ATX form factor. The system designer should perform analysis in the expected platform operating environment to assess impact on thermal solution selection.

The MCH reference design thermal solution has been optimized to meet both boundary conditions for Express Chipsets of X48 MCH and X38 MCH shown in Table 3.

**Table 3. MCH Heatsink Boundary Condition**

| Component | Airflow Speed (LFM) | Air Inlet Temperature ($T_A$)Correction Factor in ATX Platform[1] |
|---|---|---|
| Intel® X48 Express Chipset | 292 | 51.0 °C |
| Intel® X38 Express Chipset | 292 | 50.0 °C |

**NOTE:** The MCH reference design meets the higher thermal performance requirements of the 82X48 MCH. Customers can save costs by designing a heatsink compliant only to 82X38 MCH, if desired.

In ATX platforms an airflow speed of 1.48 m/s [292 lfm] is assumed to be approaching the heatsink at a 30° angle from the processor thermal solution, see Figure 5 and Figure 6 for more details. The local ambient air temperature, $T_{A,}$, at the MCH heatsink in an ATX platform is assumed to be 50.0 °C for the 82X38 MCH and 51.0 °C for the 82X48 MCH. The airflow assumed above can be achieved by using a processor heatsink providing omni directional airflow, such as a radial fin or “X” pattern heatsink. Such a heatsink can deliver airflow to both the MCH and other areas like the voltage regulator, as shown in Figure 7. In addition, MCH board placement should ensure that the MCH heatsink is within the air exhaust area of the processor heatsink.

**Note that heatsink orientation alone does not guarantee the required airflow speed will be achieved.** The system integrator should use analytical or experimental means to determine whether a system design provides adequate airflow speed for a particular MCH heatsink. This analysis should include the fan speed control algorithm that provides the airflow to the MCH.

The thermal designer must carefully select the location to measure airflow to get a representative sampling. ATX platforms need to be designed for the worst-case thermal environment, typically assumed to be 35 °C ambient temperature external to the system.

**Figure 5. ATX Boundary Conditions**

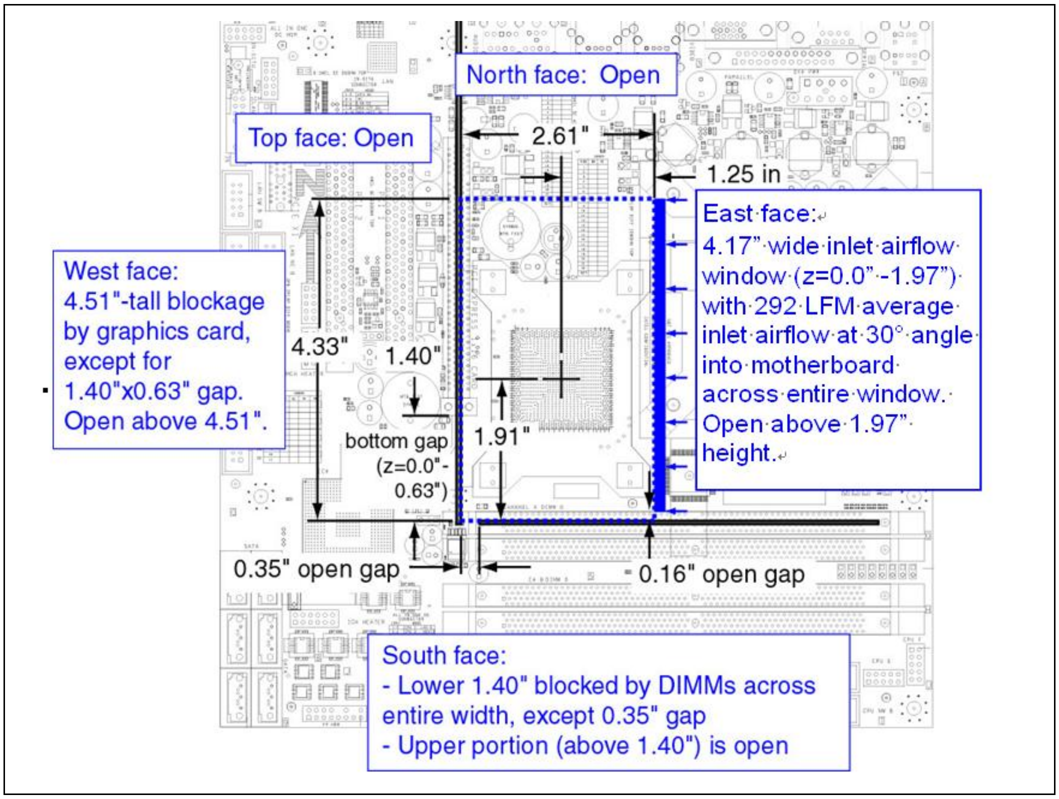


**Figure 6. Side View of ATX Boundary Conditions**

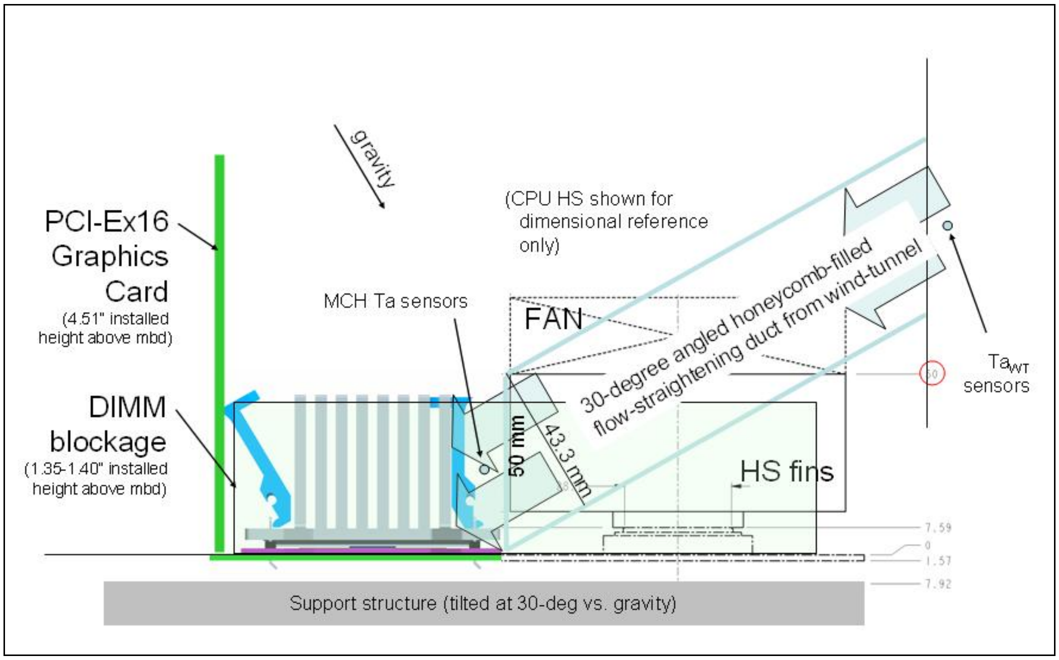
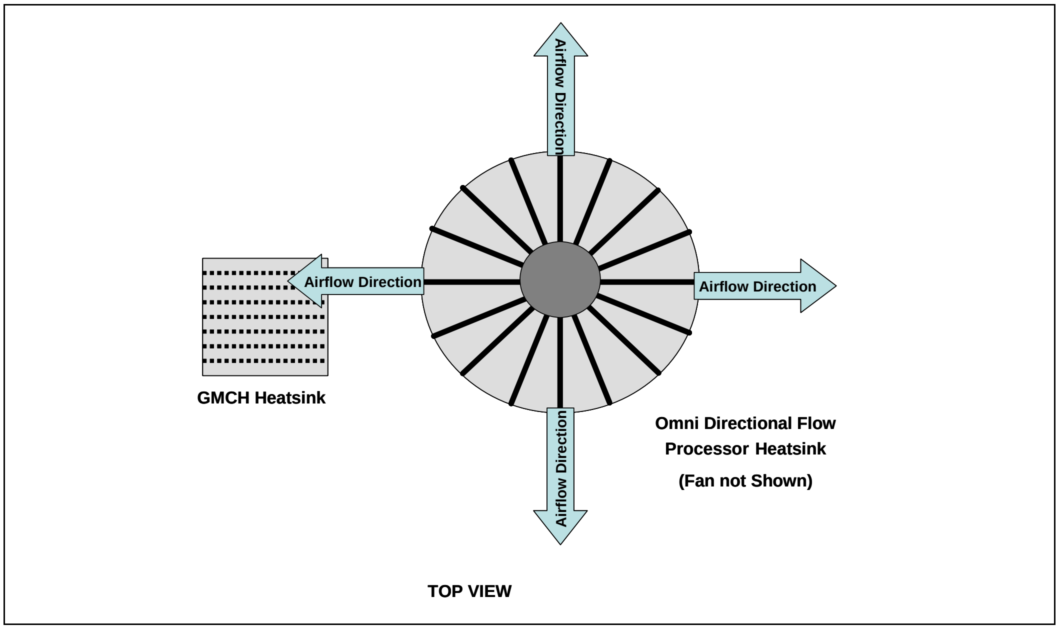



**Figure 7. Processor Heatsink Orientation to Provide Airflow to MCH Heatsink on an ATX Platform**




Other methods exist for providing airflow to the MCH heatsink, including the use of system fans and/or ducting, or the use of an attached fan (active heatsink).

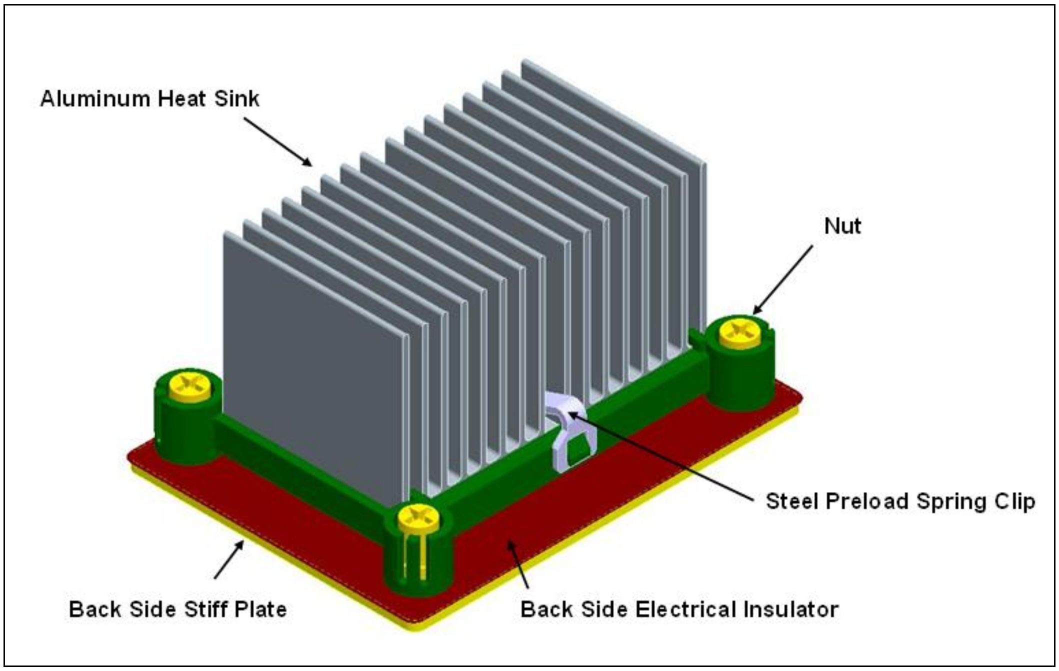
## 4.2 Reference Design Mechanical Envelope

The motherboard component keep-out restrictions for the MCH on the ATX platforms are included in Appendix C.

## 4.3 Thermal Solution Assembly

The reference thermal solution for the MCH is shown in Figure 8. The design is an aluminum extruded heatsink that utilizes four fastener nuts, a preload clip spring, a top side bracket and a back side stiffener plate assembly. Refer to Appendix C for the mechanical drawings. A thermal interface material (*Honeywell PCM45*) is pre-applied to the heatsink bottom over an area which contacts the IHS.

**Figure 8. Design Concept for Reference Heatsink**




The reference thermal solution assembly steps are:

1. Snap preload clip spring onto bracket (Figure 9).
2. Snap heatsink into spring/bracket assembly (Figure 9).
3. Place back side stiffener plate assembly to back of motherboard allowing studs to protrude through motherboard (Figure 10).
4. Place heatsink sub-assembly lining up nuts over studs (Figure 10).
5. Tighten each nut to 8 in-lb of torque alternating diagonally.

**Figure 9. Reference Heatsink Assembly Steps – Heatsink Sub-Assembly**

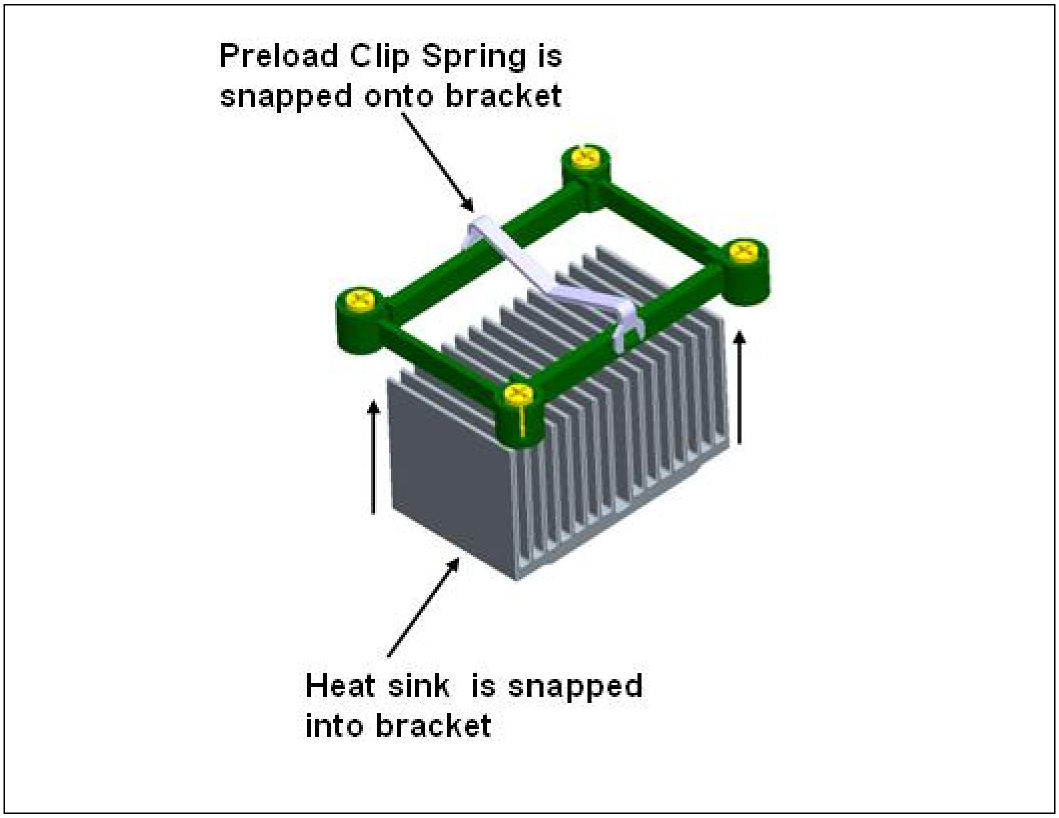
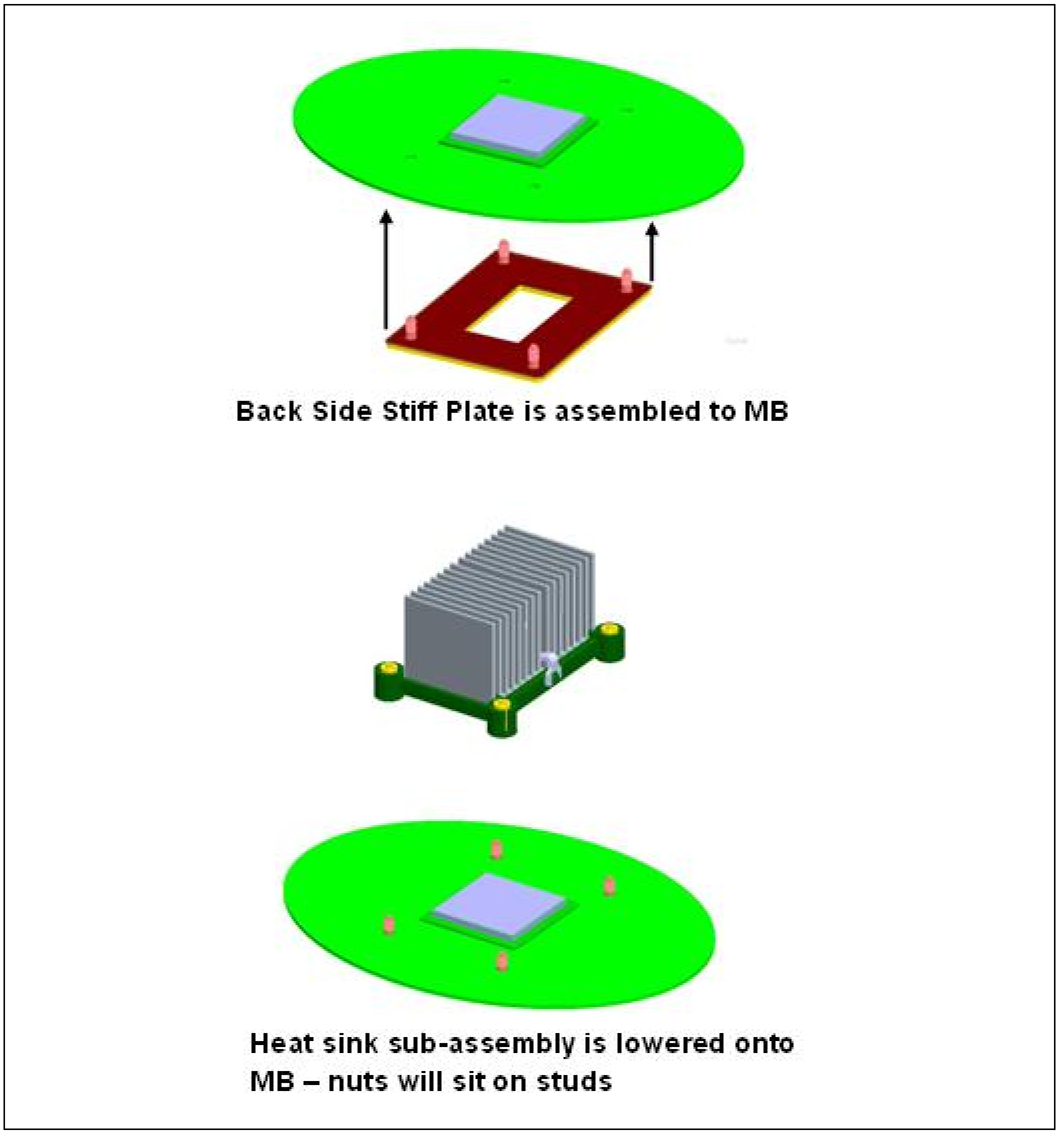


**Figure 10. Reference Heatsink Assembly Steps – Heatsink Assembly**



## 4.4 Environmental Reliability Requirements

The environmental reliability requirements for the reference thermal solution are shown in Table 4. These should be considered as general guidelines. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements.

The ATX testing will be performed with the sample board mounted on a test fixture and includes a processor heatsink with a mass of 550g. The test profiles are unpackaged board level limits.

**Table 4. ATX Reference Thermal Solution Environmental Reliability Requirements (Board Level)**

| Test[1] | Requirement | Pass/Fail Criteria[2] |
|---|---|---|
| Mechanical Shock | • 3 drops for + and - directions in each of 3 perpendicular axes (i.e., total 18 drops).<br>• Profile: 50 G, Trapezoidal waveform, 4.3 m/s [170 in/s] minimum velocity change | Visual\Electrical Check |
| Random Vibration | • Duration: 10 min/axis, 3 axes<br>• Frequency Range: 5 Hz to 500 Hz<br>• Power Spectral Density (PSD) Profile: 3.13 g RMS | Visual/Electrical Check |
| Thermal Cycling | • -40 °C to +85 °C, TBD cycles | Thermal Performance |
| Unbiased Humidity | • 85 % relative humidity / 55 °C, TBD | Visual Check |

**NOTES:**

1. The above tests should be performed on a sample size of at least 12 assemblies from 3 different lots of material.
2. Additional Pass/Fail Criteria may be added at the discretion of the user.

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# 5 Balanced Technology Extended (BTX) Thermal Solution Guidance

The BTX reference design for the MCH is equivalent to the Intel® 975X Express Chipset thermal solution. The thermal interface material, extrusion design and wire preload clip are required to meet the MCH thermal requirements. The keep out zone remains the same as used with the Intel® 975X Express Chipset (see Figure 39).

## 5.1 Balanced Technology Extended (BTX) Form Factor Operating Environment

This section provides operating environment conditions based on what has been exhibited on the Intel micro-BTX reference design. On a BTX platform, the MCH obtains in-line airflow directly from the processor thermal module. Since the processor thermal module provides less recirculation and lower inlet temperature airflow to the processor, reduced inlet ambient temperatures are also often seen at the MCH as compared to ATX. An example of how airflow is delivered to the MCH on a BTX platform is shown in Figure 11.

A set of three system level boundary conditions will be established to determine MCH thermal solution requirement.

- Low external ambient (23 °C)/ idle power for the components (Case 3). This covers the system idle acoustic condition
- Low external ambient (23 °C)/ TDP for the components (Case 2). The TMA fan speed is limited by the thermistor in the fan hub.
- High ambient (35 °C)/ TDP for the components (Case 1). This covers the maximum TMA fan speed condition.

More details on the assumed TMA airflow set points will be included in a future revision. In addition to the 3 cases listed above the analysis considered both microtower and 3”-thick ePC chassis configurations to determine the worst case: The values in Table 5 correspond to the thin ePC configuration.

**Table 5. Projected Chassis Conditions by Case**

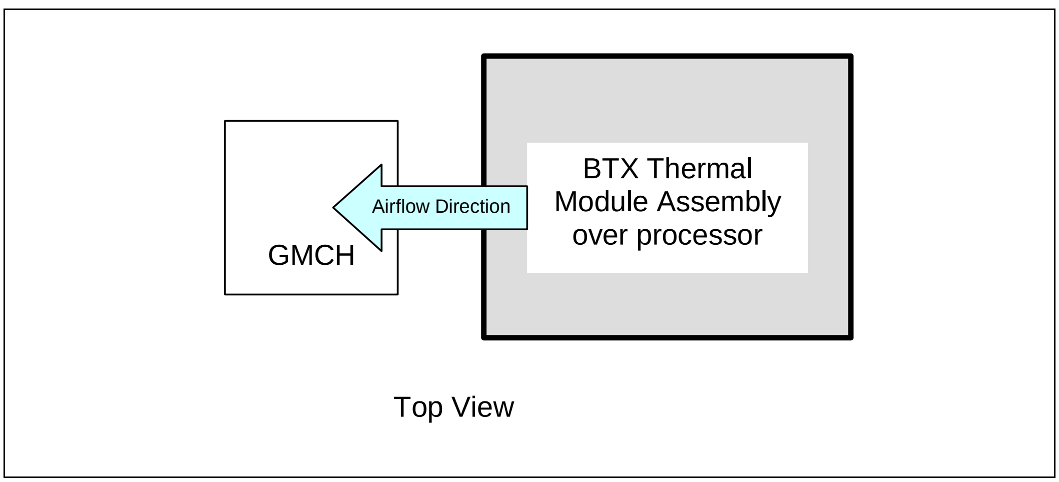
| Cases | $T_A$ into MCH heatsink (°C) | Airflow into the MCH heatsink (LFM) |
|---|---|---|
| Case 1 | 42.9 | 364 |
| Case 2 | 36.7 | 178 |
| Case 3 | 37.0 | 51.5 |

**NOTES:**
1. For all cases, a thermal solution is required on the MCH.

The customer should analyze their system design to verify their applicable boundary conditions prior to design. The thermal designer must carefully select the location to measure airflow to get a representative sampling. BTX platforms need to be designed for the worst-case thermal environment, typically assumed to be 35 °C ambient temperature external to the system.

***Note:*** The local ambient air temperature is a projection based on the power variations for a 2007 platform including processor TDPs of 65 W /95 W /130 W.

**Figure 11. Processor Heatsink Orientation to Provide Airflow to MCH Heatsink on a Balanced Technology Extended (BTX) Platform**




## 5.2 Reference Design Mechanical Envelope

The motherboard component keep-out restrictions for the MCH on BTX platforms are included in Appendix C.

## 5.3 Environmental Reliability Requirements

The current plan for BTX reference solution testing is to mount the sample board in a representative chassis with a thermal module assembly having a mass of 900g. The test profiles are unpackaged system level limits.

The environmental reliability requirements for the reference thermal solution are shown in Table 6. These should be considered as general guidelines. Validation test plans should be defined by the user based on anticipated use conditions and resulting reliability requirements.

**Table 6. Balanced Technology Extended (BTX) Reference Thermal Solution Environmental Reliability Requirements (System Level)**

| Test[1] | Requirement | Pass/Fail Criteria[2] |
|---|---|---|
| Mechanical Shock | • 2 drops for + and - directions in each of 3 perpendicular axes (i.e., total 12 drops).<br>• Profile: 25g, Trapezoidal waveform, 5.7 m/s [225 in/sec] minimum velocity change. | Visual\Electrical Check |
| Random Vibration | • Duration: 10 min/axis, 3 axes<br>• Frequency Range: .001 g2/Hz @ 5Hz, ramping to .01 g2/Hz @20 Hz, .01 g2/Hz @ 20 Hz to 500 Hz<br>• Power Spectral Density (PSD) Profile: 2.20 g RMS | Visual/Electrical Check |
| Thermal Cycling | • -40 °C to +85 °C, TBD cycles | Thermal Performance |
| Unbiased Humidity | • 85 % relative humidity / 55 °C, 500 hours | Visual Check |

**NOTES:**

1. The above tests should be performed on a sample size of at least 12 assemblies from 3 different lots of material.
2. Additional Pass/Fail Criteria may be added at the discretion of the user.
3. Mechanical Shock minimum velocity change is based on a system weight of 20 to 29 lbs.
4. For the chassis level testing the system will include: 1 HD, 1 ODD, 1 PSU, 2 DIMMs and the I/O shield.

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# Appendix A Case Temperature Reference Metrology

## A.1 Objective and Scope

This appendix defines a reference procedure for attaching a thermocouple to the IHS of FCBGA7 chipset package for $T_C$ measurement. This procedure takes into account the specific features of the FCBGA7 chipset package on the live board for which it is intended. The recommended equipment for the reference thermocouple installation, including tools and part numbers are also provided.

## A.2 Supporting Test Equipment

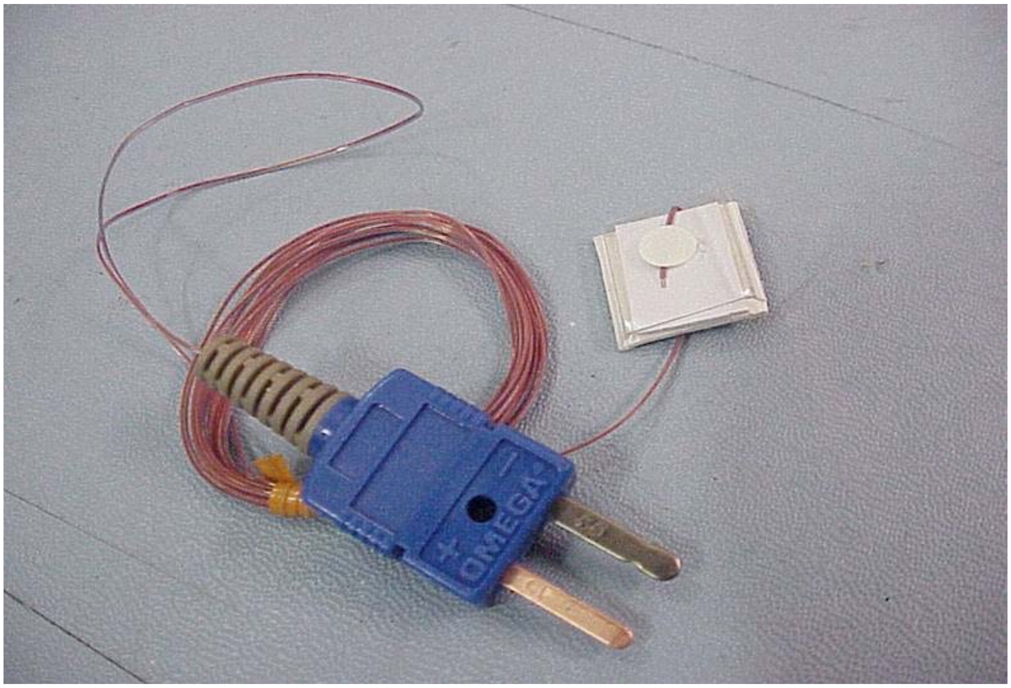
To apply the reference thermocouple attach procedure, it is recommended to use the equipment (or equivalent) given in the table below.

| Item | Description | Part Number |
|---|---|---|
| **Measurement and Output** | | |
| Microscope | Olympus* Light microscope or equivalent | SZ-40 |
| DMM | Digital Multi Meter for resistance measurement | Fluke 79 Series |
| Thermal Meter | Hand held thermocouple meter | Multiple Vendors |
| **Test Fixtures (see notes for ordering information)** | | |
| Special Modified Tip Solder Block Fixture | 40W 120V~60Hz modified soldering iron | Weller SP40L solder tool |
| **Miscellaneous Hardware (see notes for ordering information)** | | |
| Solder | Indium Corp. of America<br>Alloy 57BI / 42SN / 1AG 0.010 Diameter | 52124 |
| Flux | Indium Corp. of America | 5RMA |
| Loctite* 498 Adhesive | Super glue w/thermal characteristics | 49850 |
| Adhesive Accelerator | Loctite* 7452 for fast glue curing | 18490 |
| Kapton* Tape | For holding thermocouple in place | Not Available |
| Thermocouple | Omega *,36 gauge, "T" Type<br>(see note 2 for ordering information) | OSK2K1280/ 5SRTC-TT-T-36-72 |
| **Calibration and Control** | | |
| Ice Point Cell | Omega*, stable 0 ºC temperature source for calibration and offset | TRCIII |
| Hot Point Cell | Omega *, temperature source to control and understand meter slope gain | CL950-A-110 |

**NOTES:**

1. The Special Modified Tip Solder Block Fixture is available from Test Equipment Depot 800-517-8431.
2. The Alloy 57BI / 42SN / 1AG 0.010 Diameter solder and the solder flux are available from Indium Corp. of America 315-853-4900.
3. The Loctite* 498 Adhesive and Adhesive Accelerator are available from R.S. Hughes 916-737-7484.
4. This part number is a custom part with the specified insulation trimming and packaging requirements necessary for quality thermocouple attachment, See Figure 12. Order from Omega Eng +1-800-826-6342.

**Figure 12. Omega Thermocouple**




## A.3 Thermal Calibration and Controls

It is recommended that full and routine calibration of temperature measurement equipment be performed before attempting to perform case temperature measurements. Intel recommends checking the meter probe set against known standards. This should be done at 0ºC (using ice bath or other stable temperature source) and at an elevated temperature, around 80ºC (using an appropriate temperature source).

Wire gauge and length also should be considered as some less expensive measurement systems are heavily impacted by impedance. There are numerous resources available throughout the industry to assist with implementation of proper controls for thermal measurements.

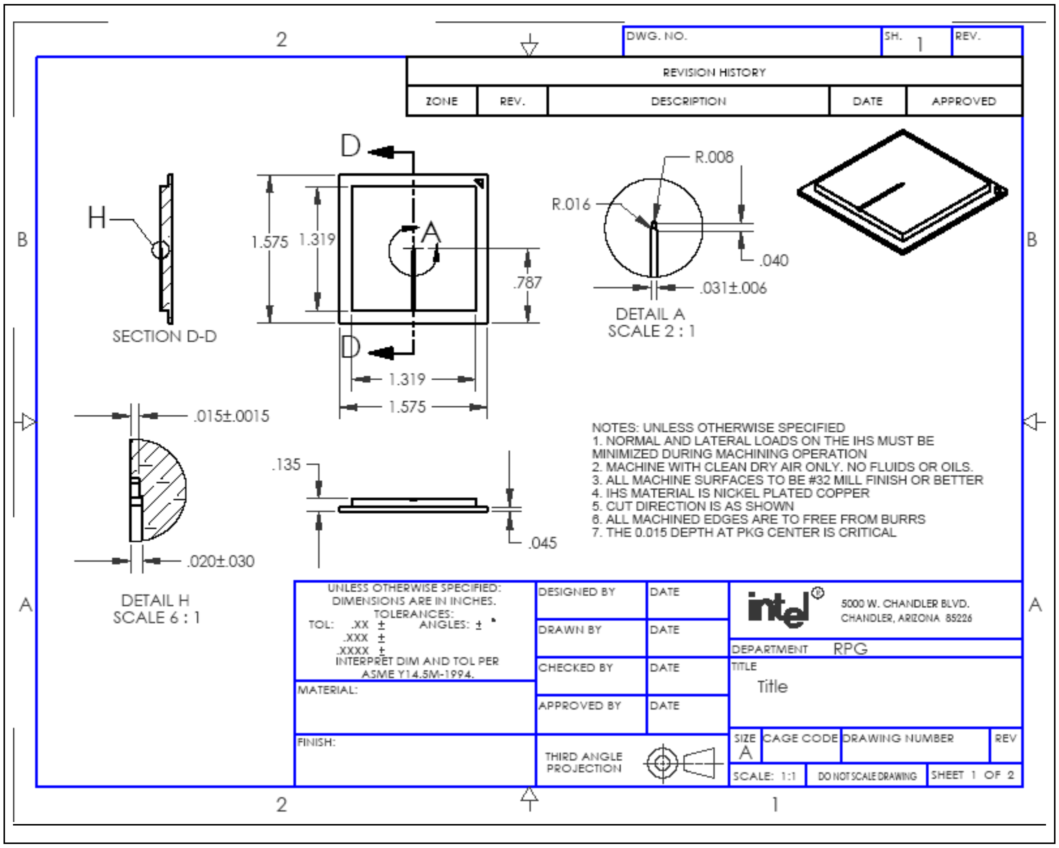
**NOTES:**

1. It is recommended to follow company standard procedures and wear safety items like glasses for cutting the IHS and gloves for chemical handling.
2. Ask your Intel field sales representative if you need assistance to groove and/or install a thermocouple according to the reference process.

## A.4 IHS Groove

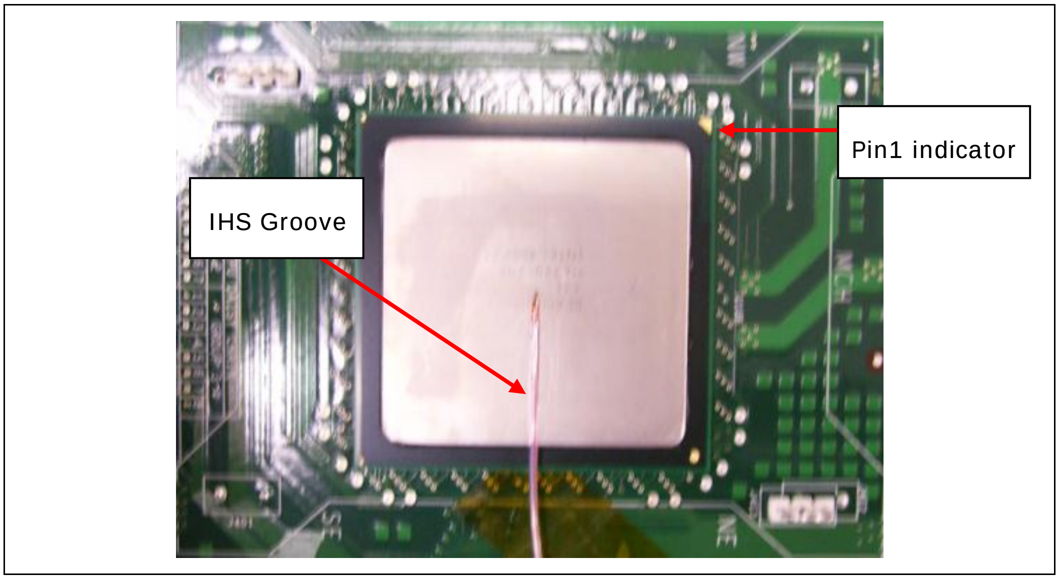
Cut a groove in the package IHS according to the drawing given in Figure 13.

**Figure 13. FCBGA7 Chipset Package Reference Groove Drawing**



The orientation of the groove relative to the package pin 1 indicator (gold triangle in one corner of the package) is shown in Figure 14 for the FCBGA7 chipset package IHS.

**Figure 14. IHS Groove on the FCBGA7 Chipset Package on the Live Board**




Select a machine shop that is capable of holding drawing specified tolerances. IHS groove geometry is critical for repeatable placement of the thermocouple bead, ensuring precise thermal measurements. A fixture plate should be used to machine the IHS groove on the FCBGA7 Chipset Package on the Live Board (Figure 15).

**Figure 15. The Live Board on the Fixture Plate**

Figure 51 and Figure 52 in Appendix C gives detailed drawings information of the fixture plate supporting for IHS groove on the FCBGA7 Chipset Package on the Live Board.

Inspect parts for compliance to specifications before accepting from machine shop.

# A.5 Thermocouple Attach Procedure

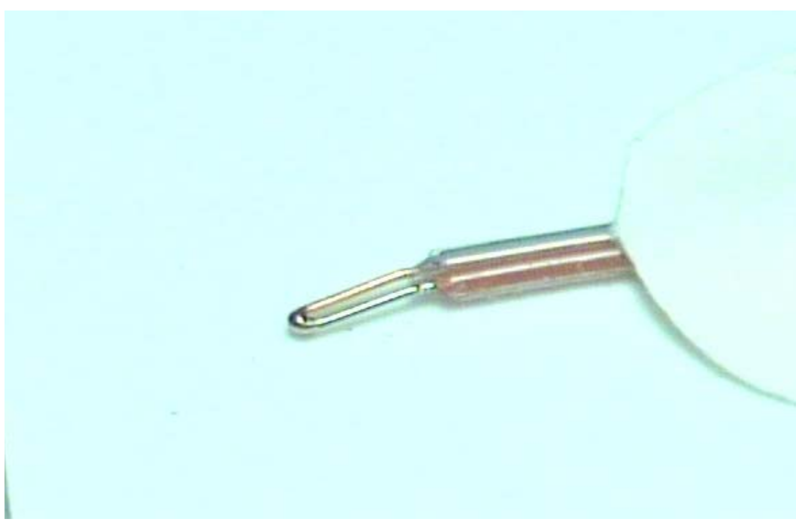
To accomplish the Thermocouple attach procedure, the following steps are required.

- Thermocouple conditioning and preparation
- Thermocouple attach to the IHS
- Soldering process
- Cleaning and completion of the Thermocouple installation.

## A.5.1 Thermocouple Conditioning and Preparation

1. Use a calibrated thermocouple as specified in Sections A.2 and A.3.
2. Under a microscope verify the thermocouple insulation meets the quality requirements. The insulation should be about 1/16 inch (0.062 ± 0.030) from the end of the bead (Figure 16).

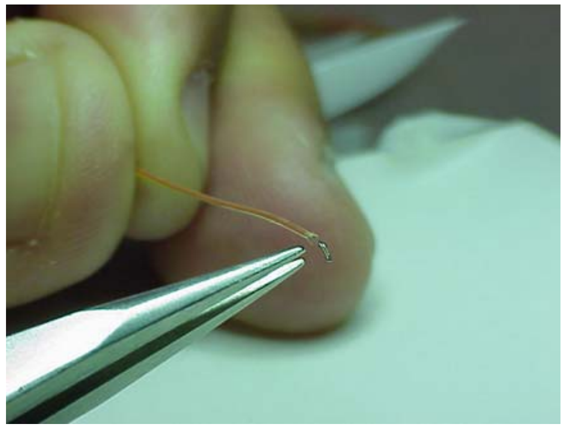
**Figure 16. Inspection of Insulation on Thermocouple**



3. Measure the thermocouple resistance by holding both contacts on the connector on one probe and the tip of thermocouple to the other probe of the DMM (measurement should be about~3.0 ohms for 36-gauge type T thermocouple).
4. Straighten the wire for about 38 mm [1 ½ inch] from the bead.

5. Using the microscope and tweezers, bend the tip of the thermocouple at approximately 10 degree angle by about 0.8 mm [.030 inch] from the tip (Figure 17).

**Figure 17. Bending the Tip of the Thermocouple**

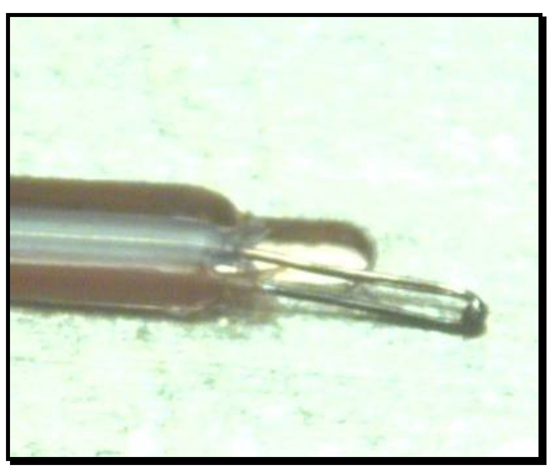


## A.5.2 Thermocouple Attachment to the IHS

6. Clean groove and IHS with Isopropyl Alcohol (IPA) and a lint free cloth removing all residues prior to thermocouple attachment.

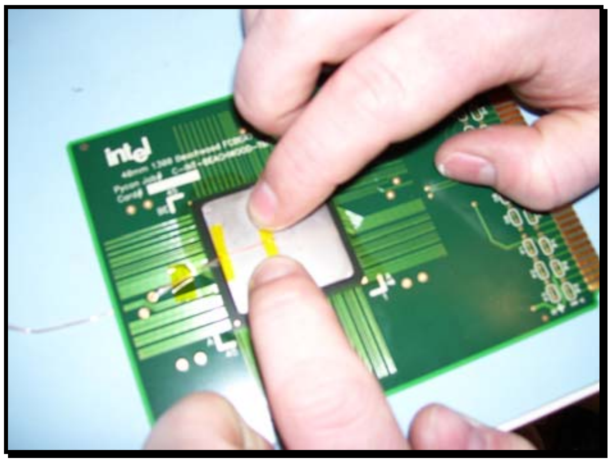
7. Place the Thermocouple wire inside the groove and let the exposed wire extend slightly over the end of groove (Figure 18).

**Figure 18. Extending Slightly the Exposed Wire over the End of Groove**



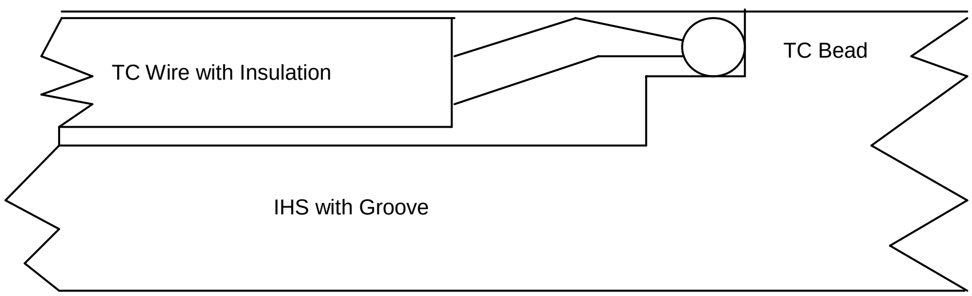
8. Bend the wire at the edge of the IHS groove and secure it in place using Kapton* tape (Figure 19).

**Figure 19. Securing Thermocouple Wire with Kapton* Tape Prior to Attach**



9. Verify under the microscope that the Thermocouple bead is still slightly bent, if not, use a fine point tweezers to put a slight bend on the tip. The purpose of this step is to ensure the Thermocouple tip is in contact with the bottom of groove ().

**Figure 20. Detailed Thermocouple Bead Placement**




10. Place the device under the microscope to continue with the process.

11. Using tweezers or a finger, slightly press the wire down inside the groove for about 5 mm from tip and place small piece of Kapton* tape to hold the wire inside the groove (Figure 21).

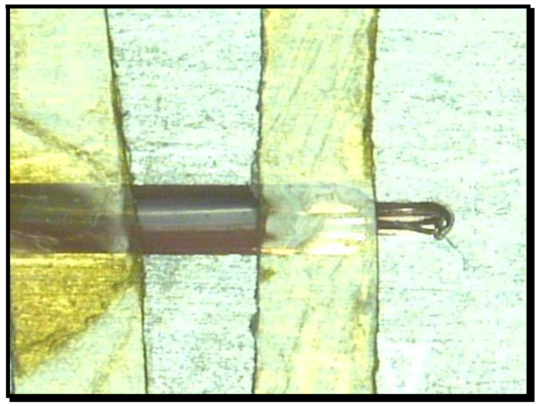
**Figure 21. Tapes Installation**


12. Thermocouple bead is placed into the bottom of the groove (Figure 22) and a small piece of tape is installed to secure it under the microscope to perform this task.

**Figure 22. Placing Thermocouple Bead into the Bottom of the Groove**

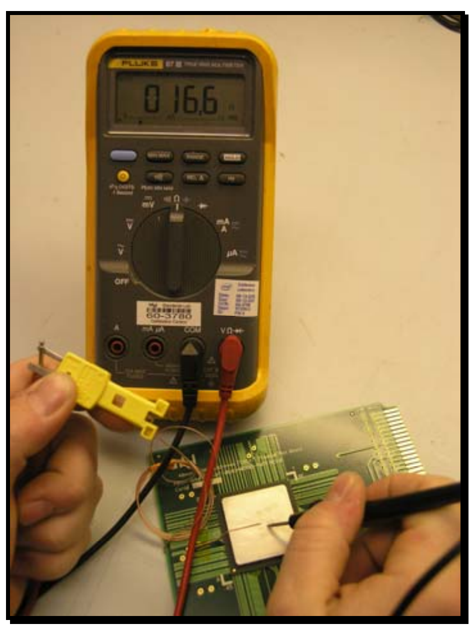
13. Place a second small piece of Kapton* tape on top of the IHS where it narrows at the tip. This tape will create a solder dam and keep solder from flowing down the IHS groove during the melting process (see Figure 23).

**Figure 23. Second Tape Installation**



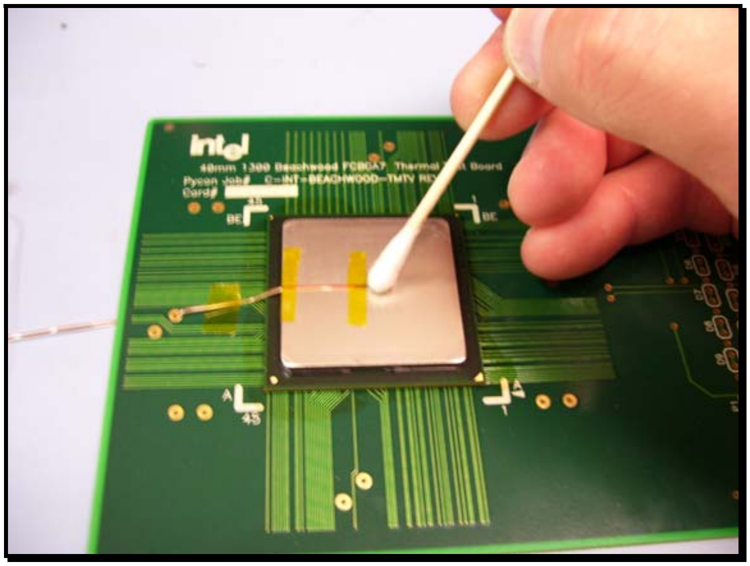
14. Measure resistance from the Thermocouple connector (hold both wires to a DMM probe) to the IHS surface, this should display the same value as read during Thermocouple conditioning Section A.5.1 step 3. This step insures the bead is still making good contact to the IHS (Figure 24).

**Figure 24. Measuring Resistance between Thermocouple and IHS**



15. Using a fine point device such as a toothpick, place a small amount of Indium paste Flux on the Thermocouple bead (Figure 25).

**Figure 25. Adding a Small Amount of Past Flux to the Bead for Soldering**



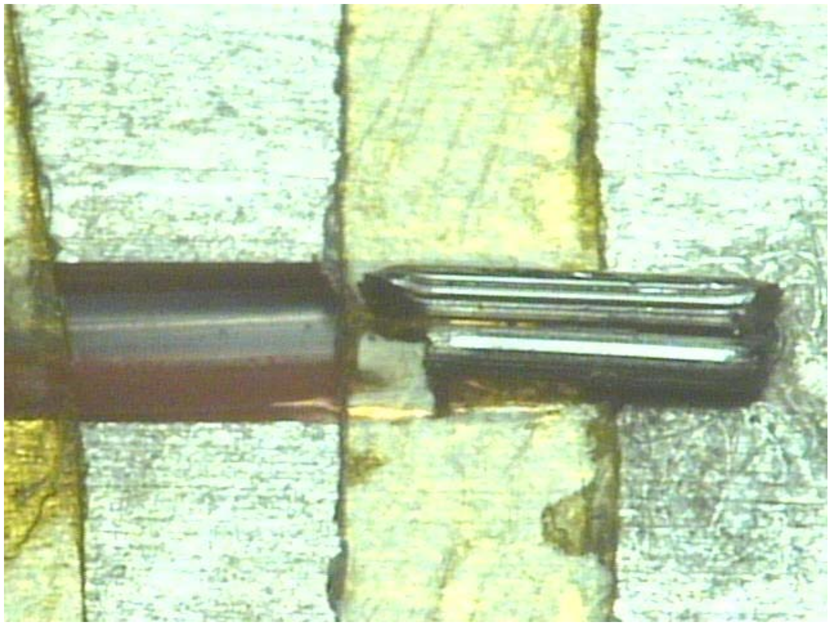

**NOTES:** Make sure you are careful to keep solder flux from spreading on the IHS surface or down the groove. It should be contained to the bead area and only the tip (narrow section of the groove). This will keep the solder from flowing onto the top of the device or down the groove to the insulation area.

16. Cut two small pieces of solder 1/16 inch (0.065 inch / 1.5 mm) from the roll using tweezers to hold the solder while cutting with a fine blade (Figure 26).

**Figure 26. Cutting Solder**

17. Place the two pieces of solder in parallel, directly over the thermocouple bead (Figure 27).

**Figure 27. Positioning Solder on IHS**



18. Measure the resistance from the thermocouple end wires again using the DMM (refer to Section A.5.1 step 3) to ensure the bead is still properly contacting the IHS.

## A.5.3 Solder Process

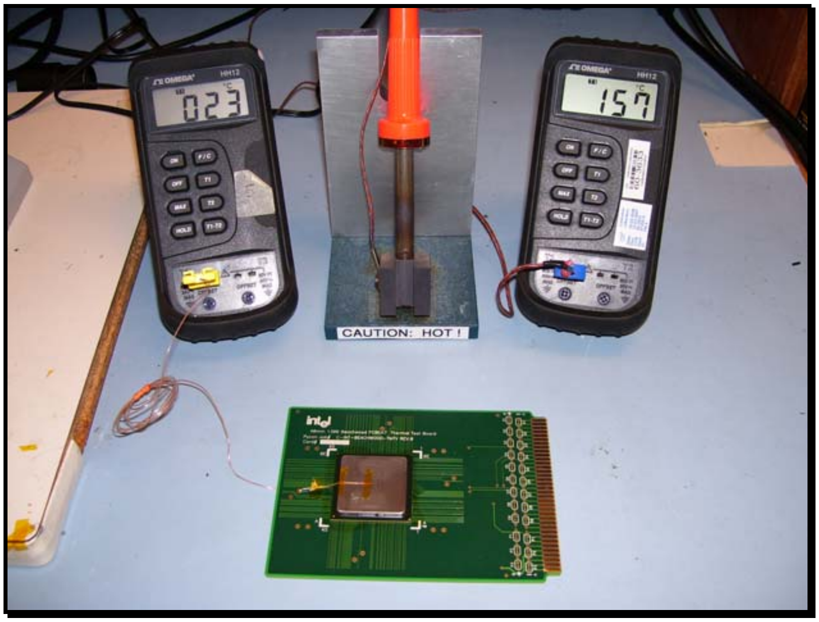
19. Turn on the Solder Block station and let it heat up to 170 ºC ± 5 ºC.

***Note:*** The heater block temperature must be set at a greater temperature to ensure that the solder on the IHS can reach 150 ºC –155 ºC. Be sure to monitor the Thermocouple meter when waiting for solder to flow. Damage to the package may occur if a temperature of 155 ºC is exceeded on the IHS.

20. Attach the tip of the Thermocouple to the solder block (perform this before turning on the solder station switch) and connect to a Thermocouple meter to monitor the temperature of the block (Figure 28).

21. Connect (Thermocouple being installed) to a second Thermocouple meter to monitor the IHS temperature and make sure this does not exceed 155 ºC at any time during the process (Figure 28).

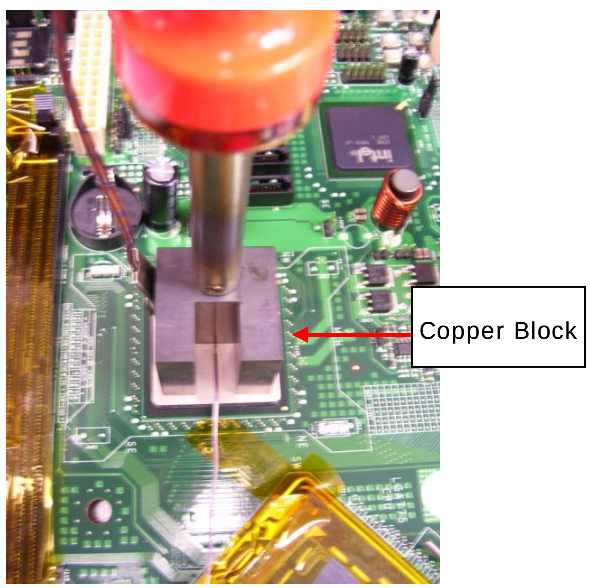
**Figure 28. Solder Block Setup**




**NOTES:** Device in place, 2 temperature monitoring meters, and heater block fixture. The heater block is currently reading 157 ºC and the Thermocouple inside IHS. is reading 23 ºC

22. Place the solder fixture on the IHS device (Figure 29).

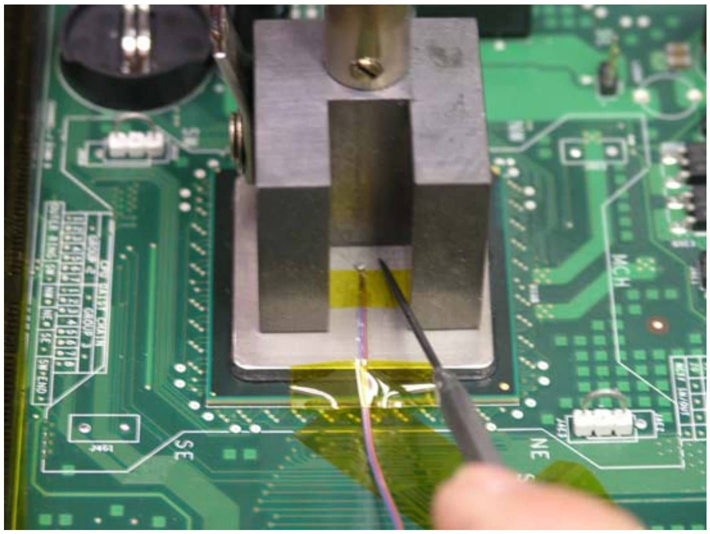
**Figure 29. Observing the Solder Melting**




**NOTES:** Don't touch the cooper block at any time as this is very hot.

23. Move a magnified lens light close to the device to get a better view when the solder starts melting. Manually assist this if necessary as the solder sometimes tends to move away from the end of the groove. Use fine tip tweezers to push solder into the end of groove until a solder ball is built up (Figure 30).

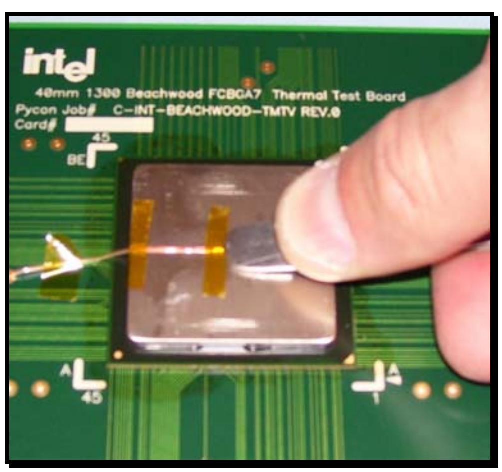
**Figure 30. Pushing Solder back into the End of Groove**



**NOTES:** The target IHS temperature during reflow is 150 °C ±3 °C. At no time should the IHS temperature exceed 155 °C during the solder process as damage to the device may occur.

24. Lift the solder block and magnified lens, quickly rotate the device 90 degrees clockwise and use the back side of the tweezers to press down on the solder. This will force out excess solder (Figure 31).

**Figure 31. Removing Excess Solder**



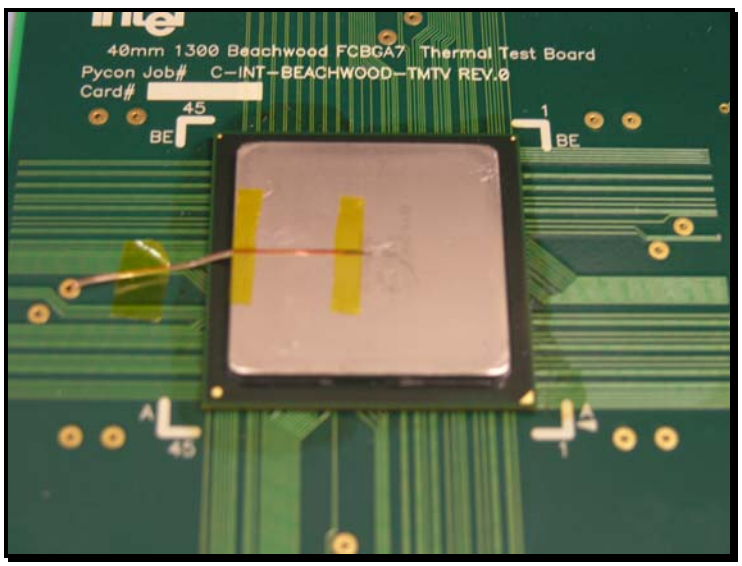
25. Allow the device to cool down. Blowing compressed air on the device can accelerate the cooling time. Monitor the device IHS temperature with a handheld meter until it drops below 70 °C before moving it to the microscope for the final steps.

### A.5.4 Cleaning & Completion of Thermocouple Installation

26. Remove the Kapton* tape with tweezers (avoid damaging the wire insulation) and straighten the wire to insert the remaining portion in the groove for the final gluing process.

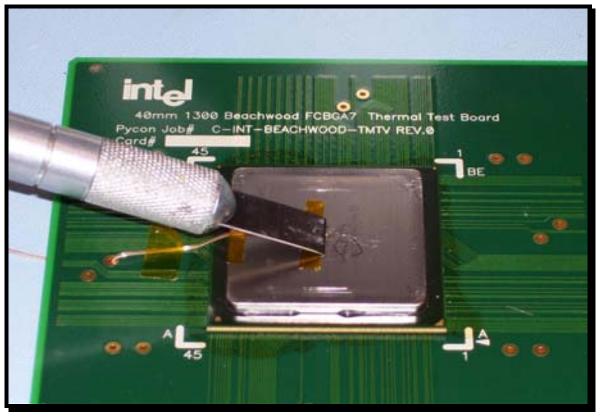
***Note:*** The wire needs to be straight so it doesn't sit above the IHS surface at any time (Figure 32).

**Figure 32. Thermocouple Placed into Groove**



27. Using a blade, carefully shave the excess solder above the IHS surface. Only shave in one direction until solder is flush with the groove surface (Figure 33).

**Figure 33. Removing Excess Solder**




**NOTES:**

1. Always insure tools are very sharp and free from any burrs that may scratch the IHS surface. It is a good practice to minimize any surface scratching or other damage during this process.
2. Shaving excess solder to insure the IHS surface is flat and will mate properly with the heat sink surface. Scratches and protrusions may impact the thermal transfer from IHS to the heat sink under

28. Clean the surface of the IHS with Alcohol and wipes, use compressed air to remove any remaining contaminants.

29. Fill the rest of the groove with Loctite* 498 Adhesive. Verify under the microscope that the Thermocouple wire is below the surface along the entire IHS groove (Figure 34).

**Figure 34. Filling Groove with Adhesive**

30. To speed up the curing process apply Loctite* Accelerator on top of the Adhesive and let it set for a couple of minutes.

31. Using a blade carefully shave any Loctite* left above the IHS surface; take into consideration instructions from step 27.

***Note:*** The adhesive shaving process should be performed when the glue is partially cured but still soft (about 1 hour after applying). This will keep the adhesive surface flat and smooth with no pits or voids. If you have void areas in the groove, refill them and shave the surface a second time.

32. Clean the IHS surface with Alcohol and keep the Thermocouple wire properly managed to avoid insulation damage kinks and tangling.

33. Once again, measure resistance from the Thermocouple connector (hold both wires to a DMM probe) to the IHS surface, this should display the same value as read during Thermocouple conditioning Section A.5.1 step 3. This step insures the bead is still making good contact to the IHS after attachment is complete.

34. Wind the thermocouple wire into loops and now it's ready to be used for thermal testing use (Figure 35).

**Figure 35. Finished Thermocouple Installation**

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# Appendix B Enabled Suppliers

Enabled suppliers for the MCH reference thermal solution are listed in Table 7 and Table 8. The supplier contact information is listed in Table 9.

***Note:*** These vendors and devices are listed by Intel as a convenience to Intel's general customer base, but Intel does not make any representations or warranties whatsoever regarding quality, reliability, functionality, or compatibility of these devices. This list and/or these devices may be subject to change without notice.

**Table 7. ATX Intel Reference Heatsink Enabled Suppliers for Intel® 82X38 and 82X48 MCH**

| ATX Items | Intel PN | AVC | CCI | Foxconn | Wieson |
|---|---|---|---|---|---|
| Heatsink Assembly | D97870-001 | | 00C92780202 | | |

**Table 8. BTX Intel Reference Heatsink Enabled Suppliers for Intel® 82X38 and 82X48 MCH**

| BTX Items | Intel PN | AVC | CCI | Foxconn | Wieson |
|---|---|---|---|---|---|
| Heatsink assembly (HS, wire clip & TIM) | D34258-001 | S905Y00001 | 00I833201A | 2ZQ99-066 | |
| Anchor (Lead Free) | A13494-008 | | | HB9703E-DW | G2100C888-064H |

### Table 9. Supplier Contact Information

| Supplier | Contacts | Phone | Email |
|---|---|---|---|
| AVC (Asia Vital Components) | David Chao | +886-2-2299-6930 ext. 7619 | david_chao@avc.com.tw |
| | Raichel Hsu | +886-2-2299-6930 ext. 7630 | raichel_hsi@avc.com.tw |
| CCI(Chaun Choung Technology) | Monica Chih | +886-2-2995-2666 | monica_chih@ccic.com.tw |
| | Harry Lin | (714) 739-5797 | hlinack@aol.com |
| Foxconn | Jack Chen | (408 919-6121 | jack.chen@foxconn.com |
| | Wanchi Chen | (408) 919-6135 | wanchi.chen@foxconn.com |
| Wieson Technologies | Chary Lee | +886-2-2647-1896 ext. 6684 | chary@wieson.com |
| | Henry Liu | +886-2-2647-1896 ext. 6330 | henry@wieson.com |

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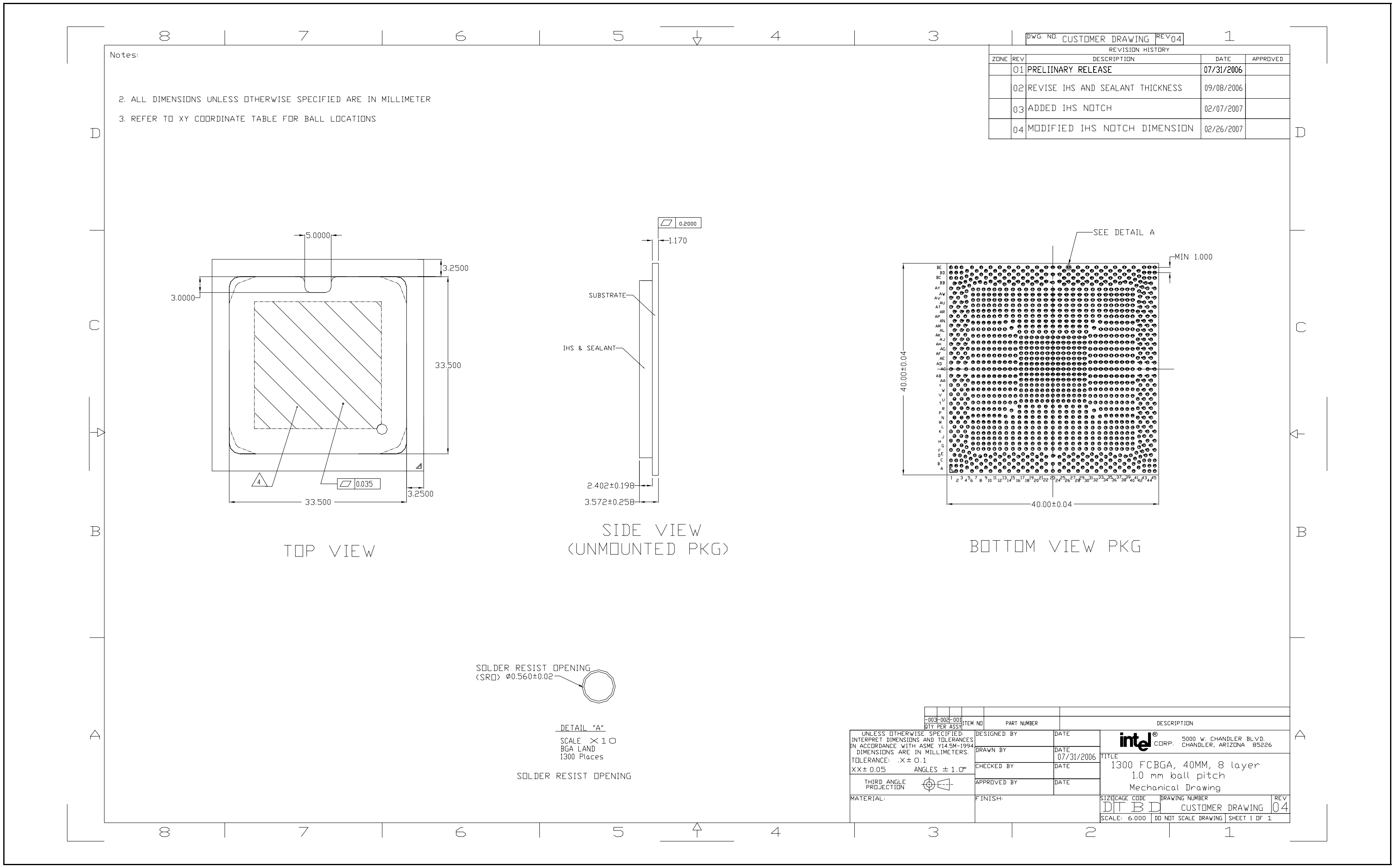
# Appendix C Mechanical Drawings

The following table lists the mechanical drawings available in this document.

## Figure 36. MCH Package Drawing



## Figure 37. Intel® X38 and X48 Express Chipset Motherboard Component Top-Side Keep-Out Restrictions for ATX Platform

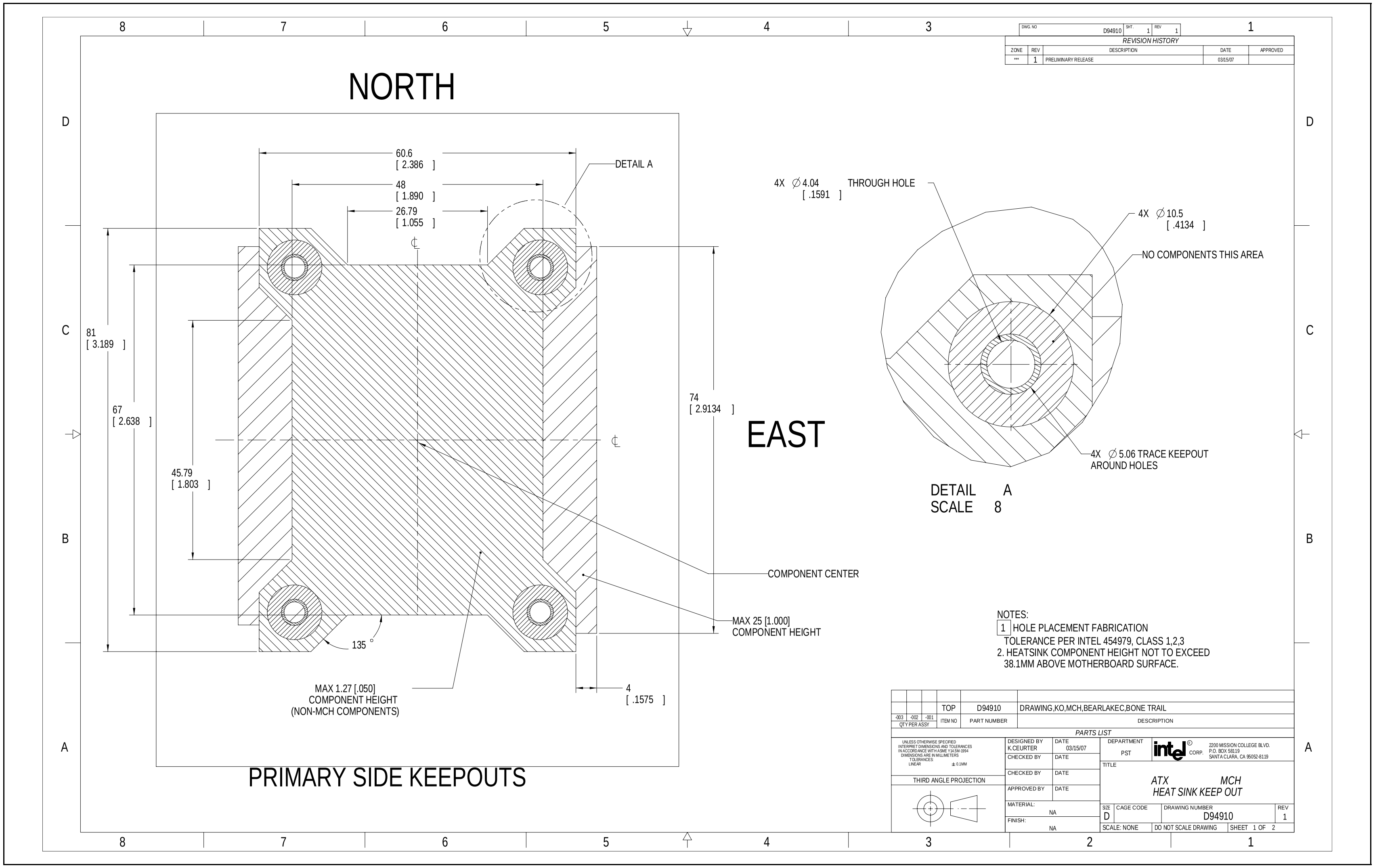
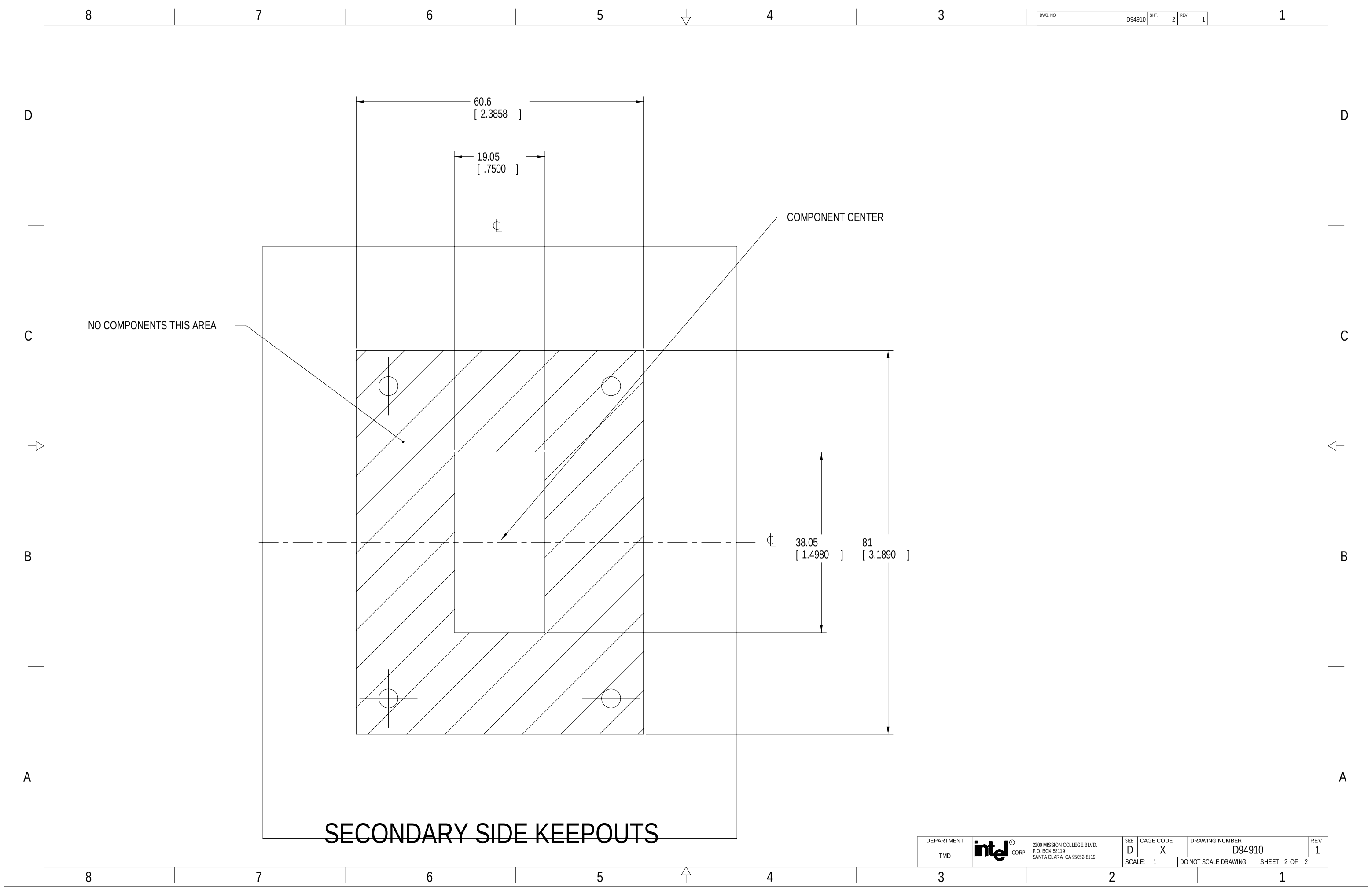
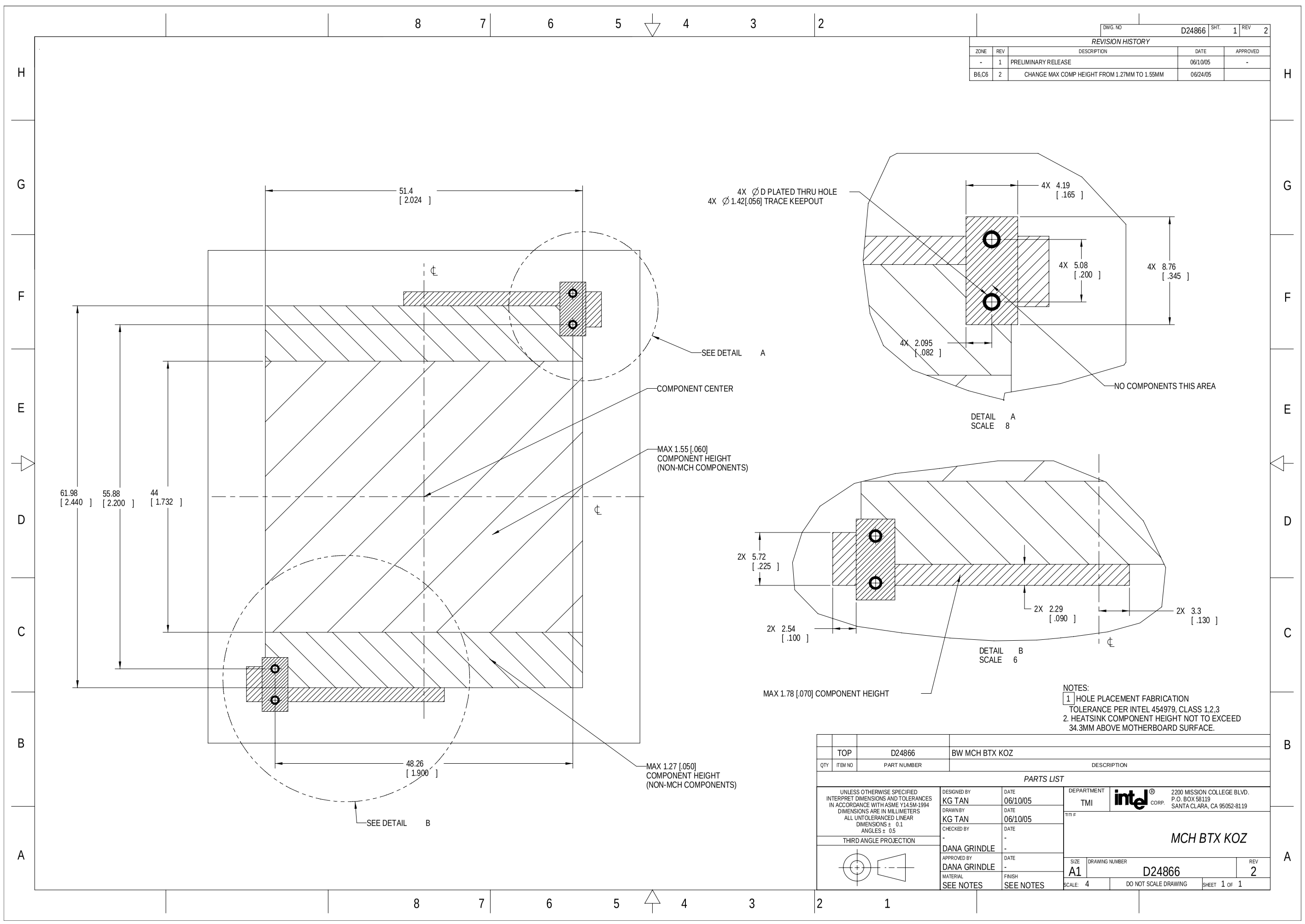


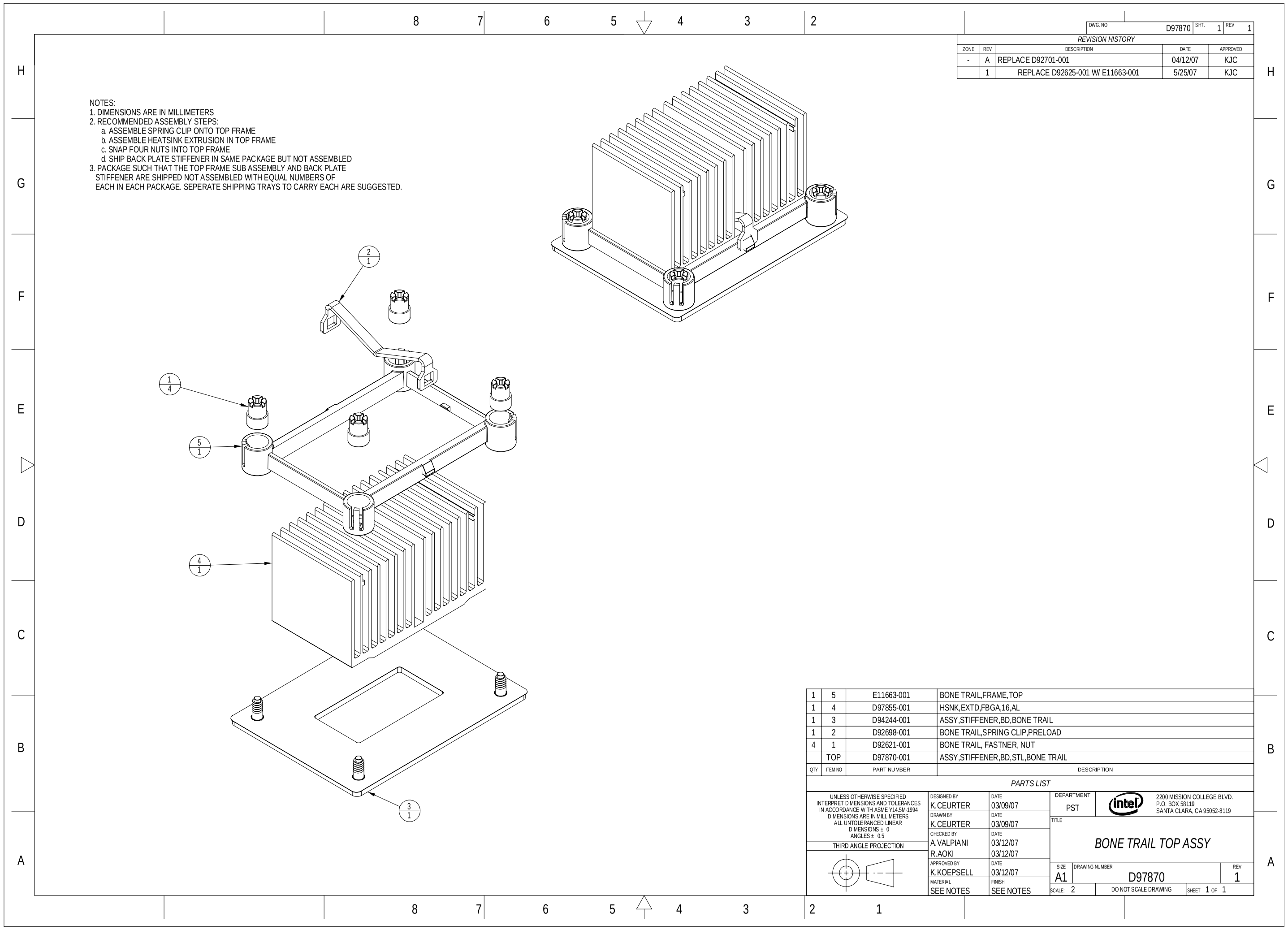
Figure 38. Intel® X38 and X48 Express Chipset Motherboard Component Backside Keep-Out Restrictions for ATX Platform



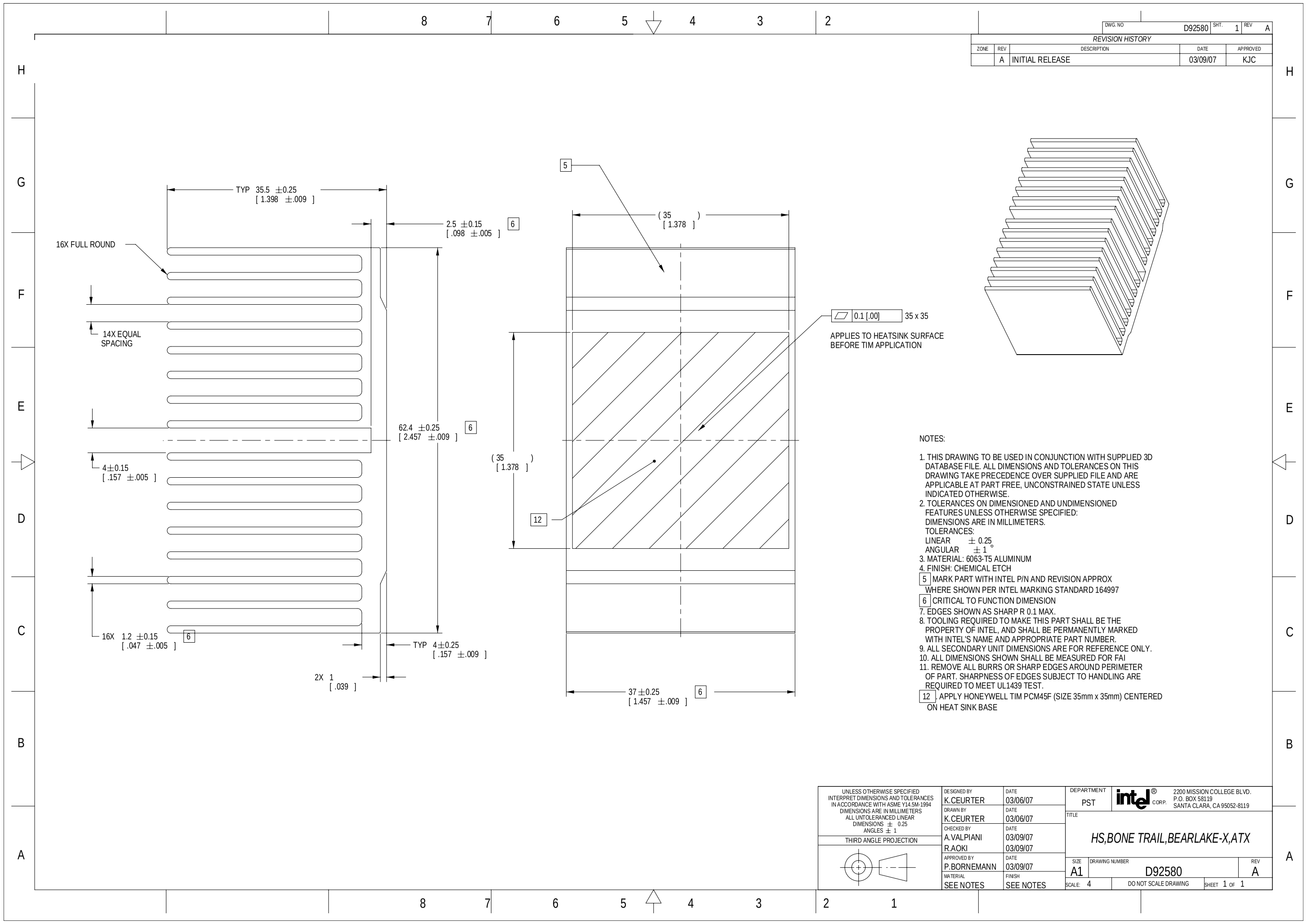
## Figure 39. Intel® X38 and X48 Express Chipset Motherboard Component Keep-Out Restrictions for Balanced Technology Extended (BTX) Platforms



## Figure 40. MCH Reference Heatsink Assembly for ATX Platforms



## Figure 41. MCH Reference Heatsink for ATX Platforms



## Figure 42. MCH Reference Heatsink for ATX Platforms – Spring Preload Clip

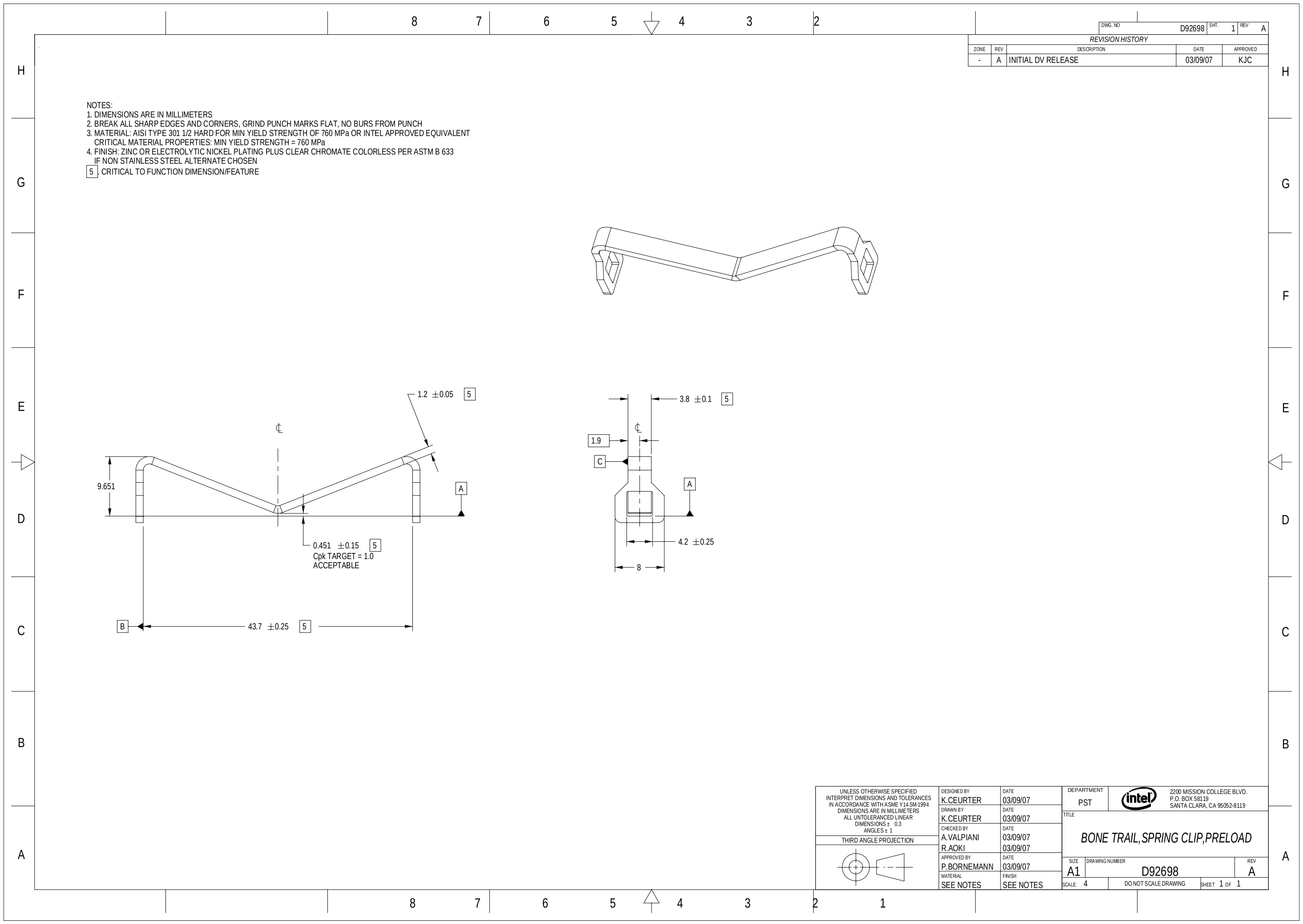
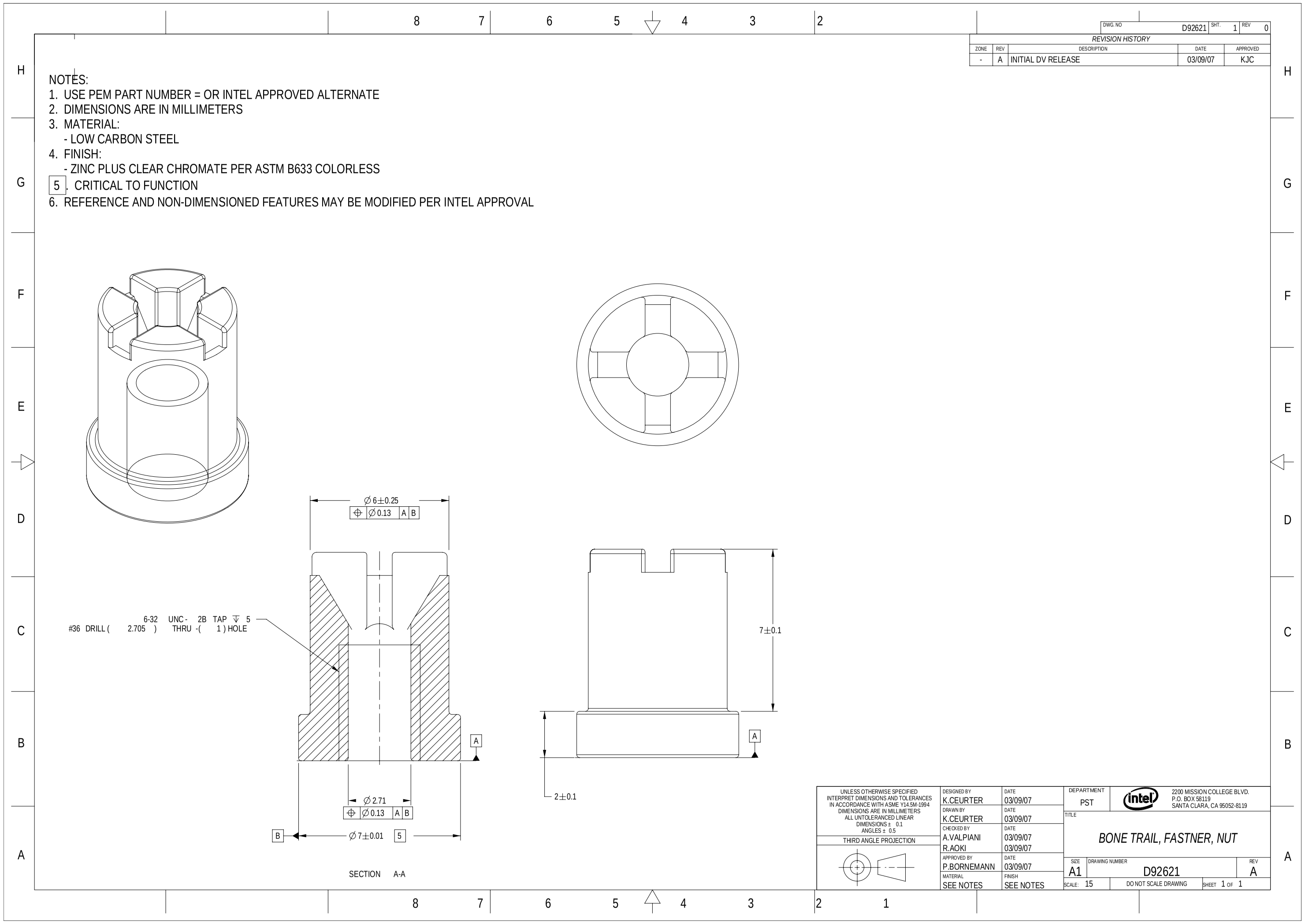
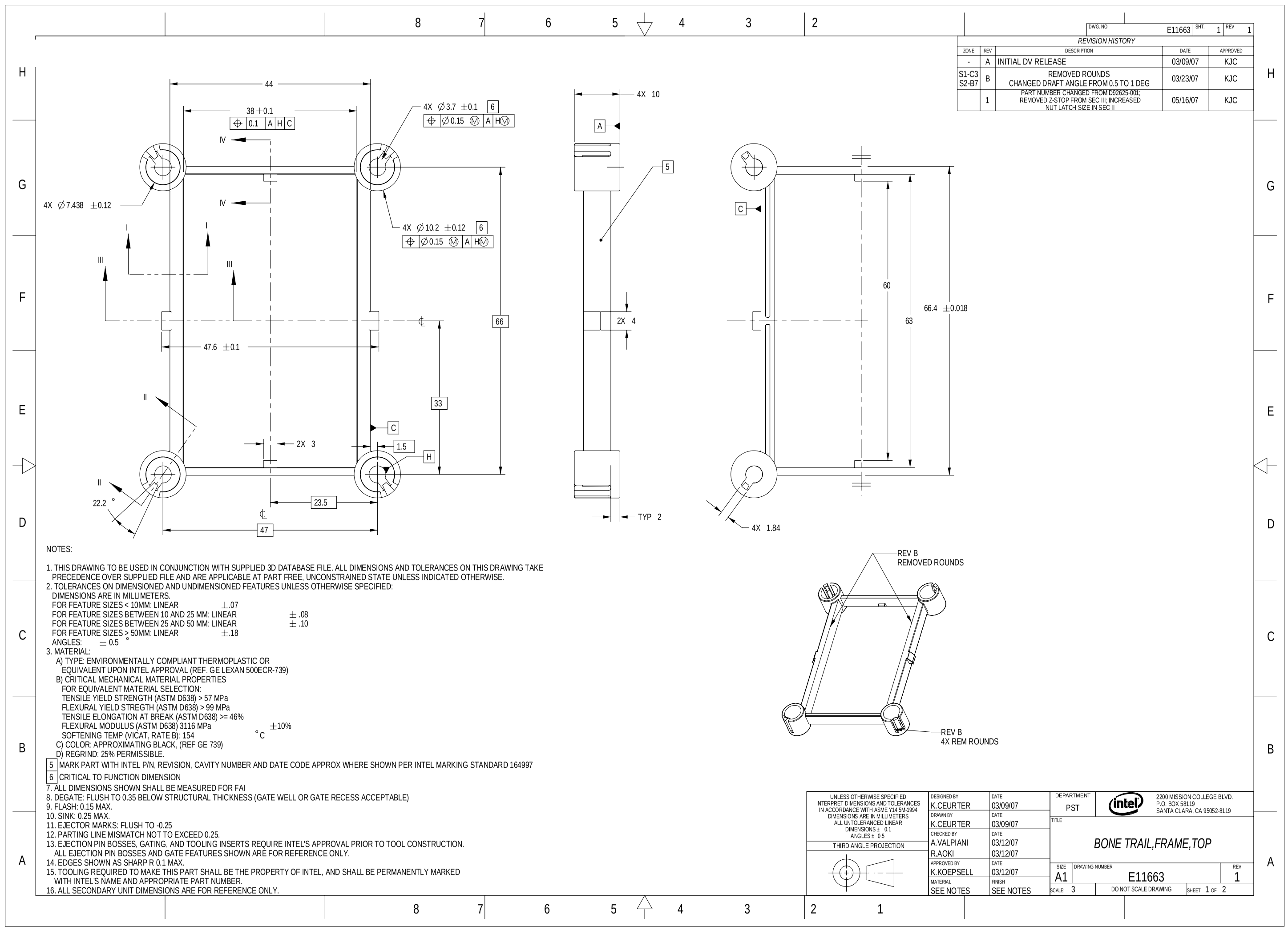


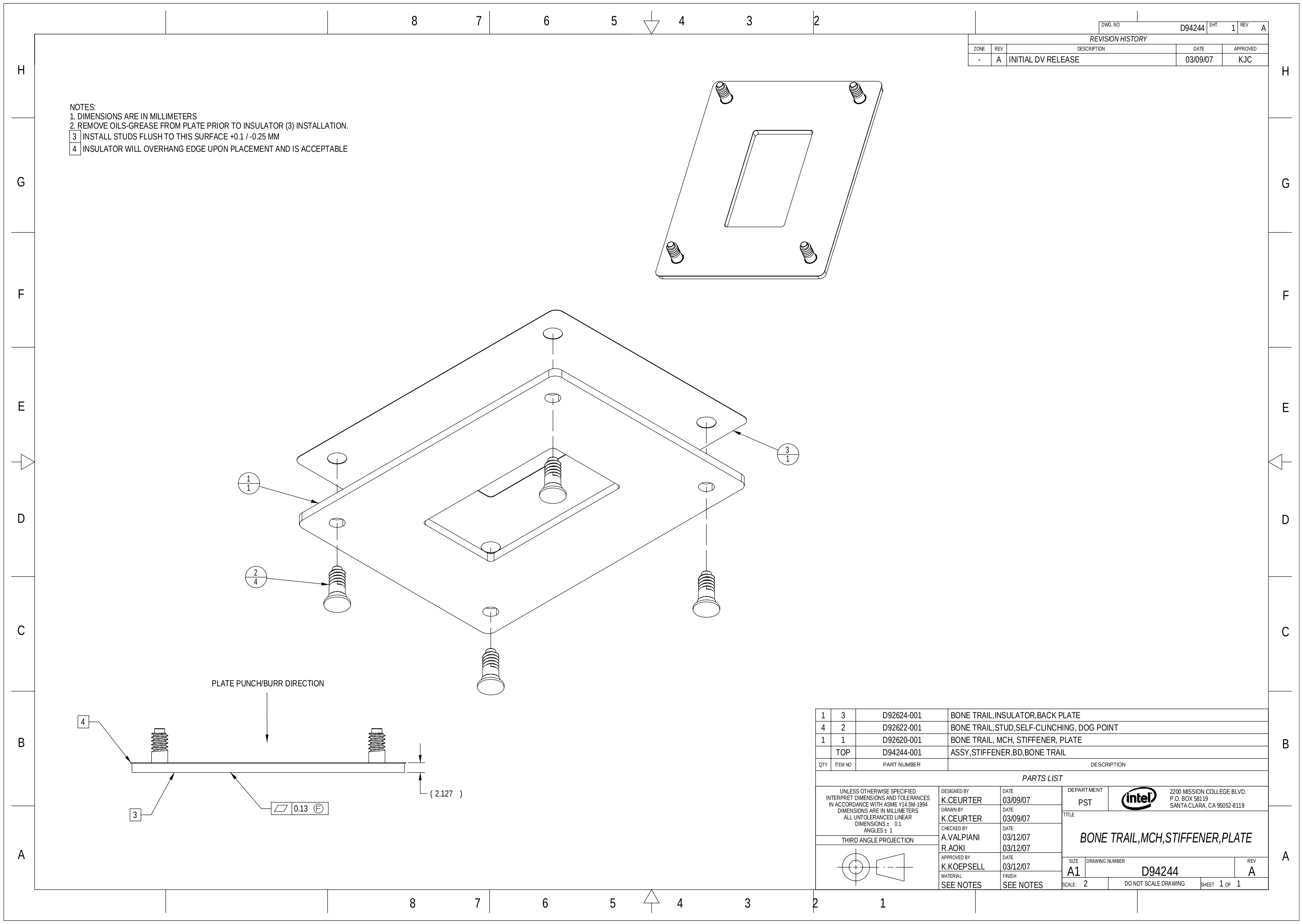
**Figure 43. MCH Reference Heatsink for ATX Platforms – Fastener Nut**



## Figure 44. MCH Reference Heatsink for ATX Platforms – Top Side Bracket



## Figure 45. MCH Reference Back Side Stiffener Plate Assembly for ATX Platforms



## Figure 46. MCH Reference Back Side Stiffener Plate for ATX Platforms

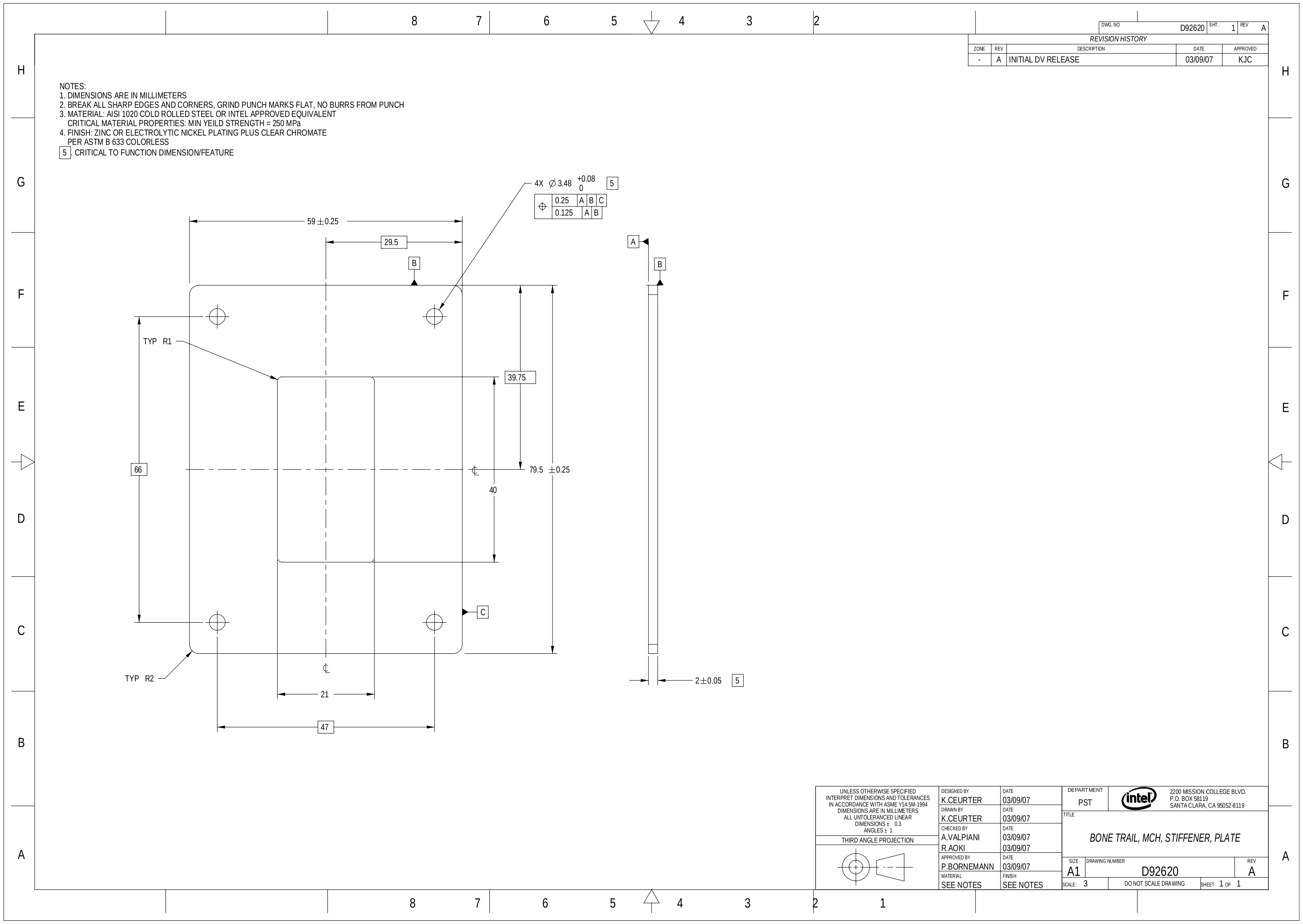


Figure 47. MCH Reference Back Side Stiffener Plate for ATX Platforms – Back Side Electrical Insulator

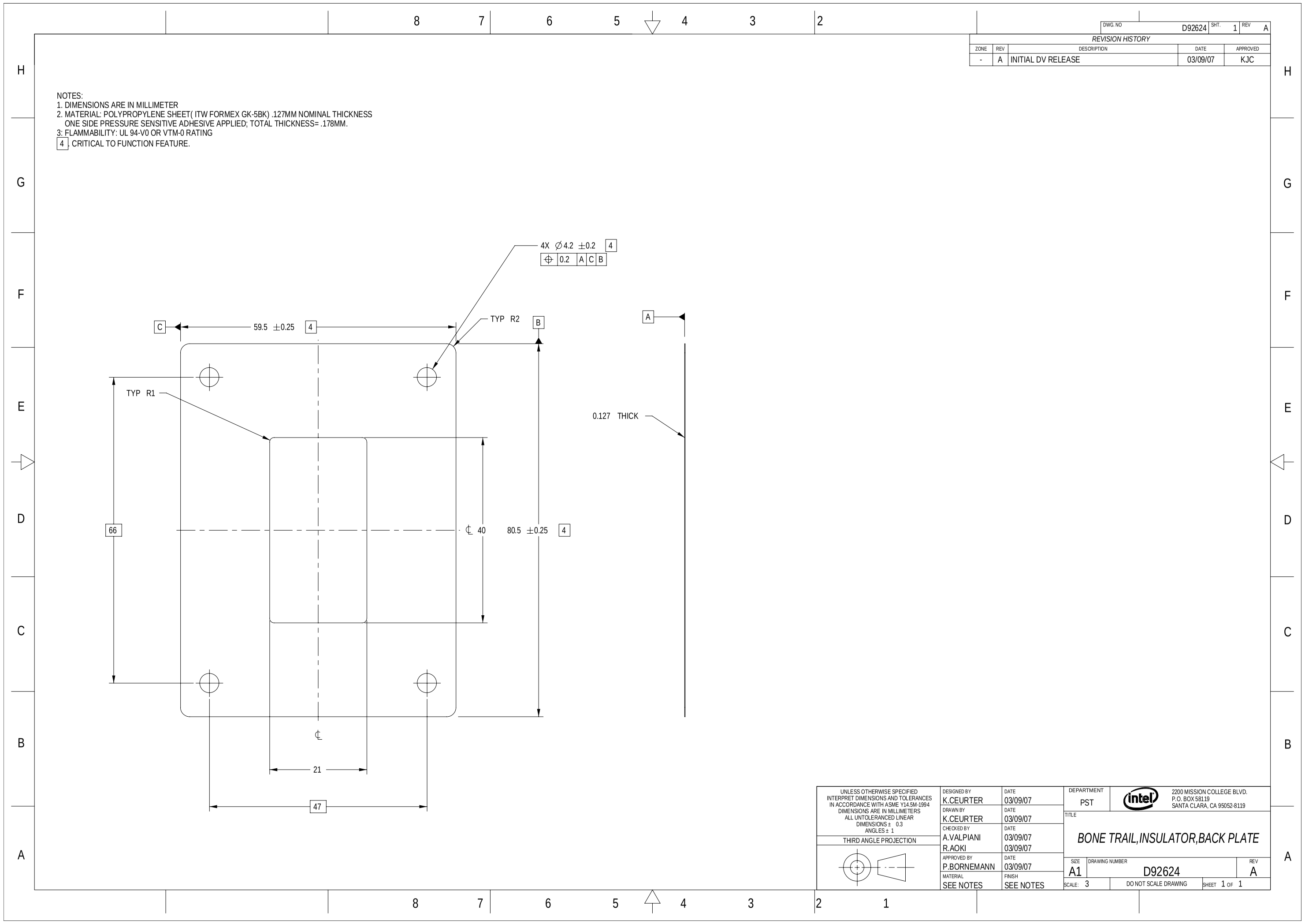
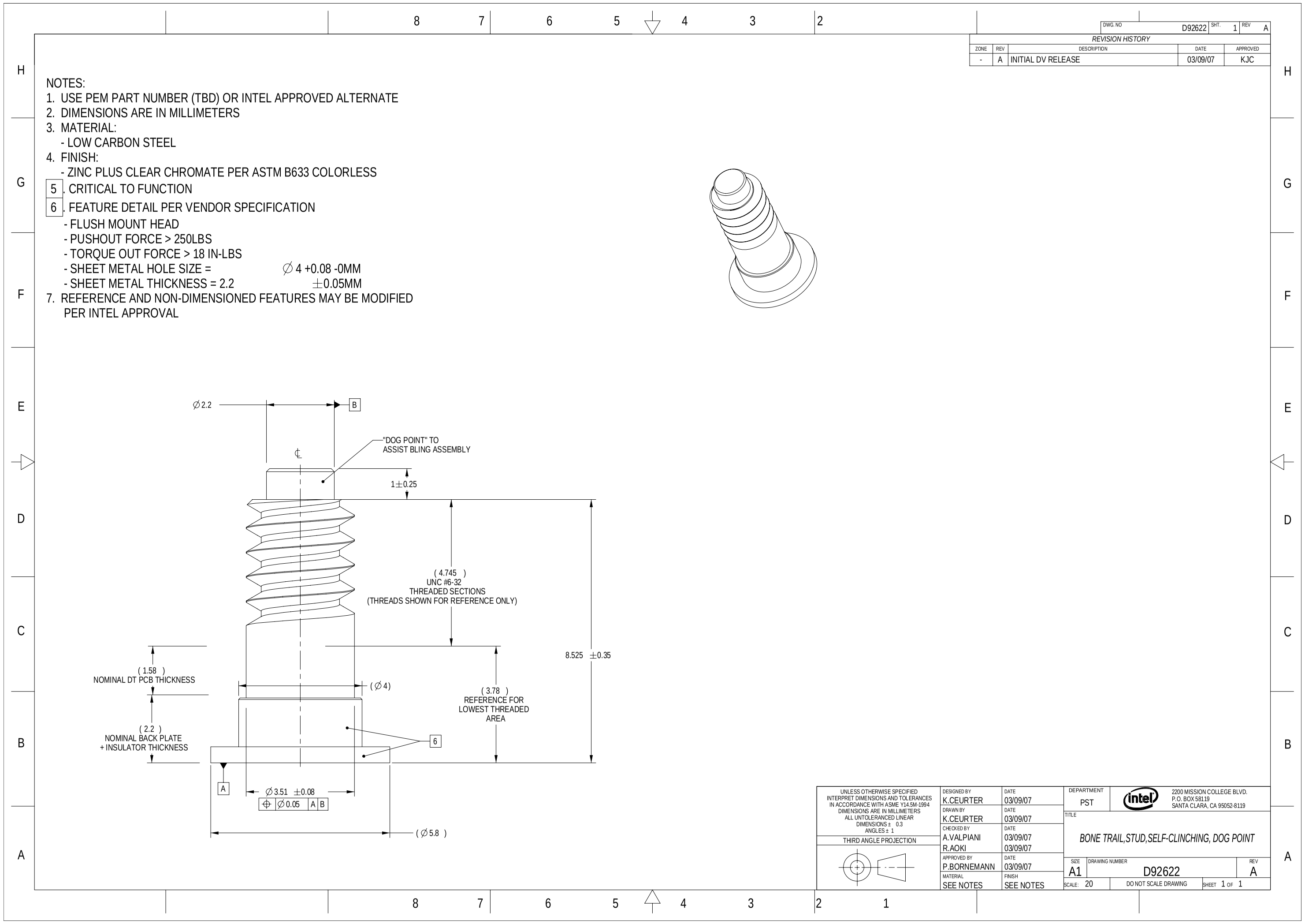
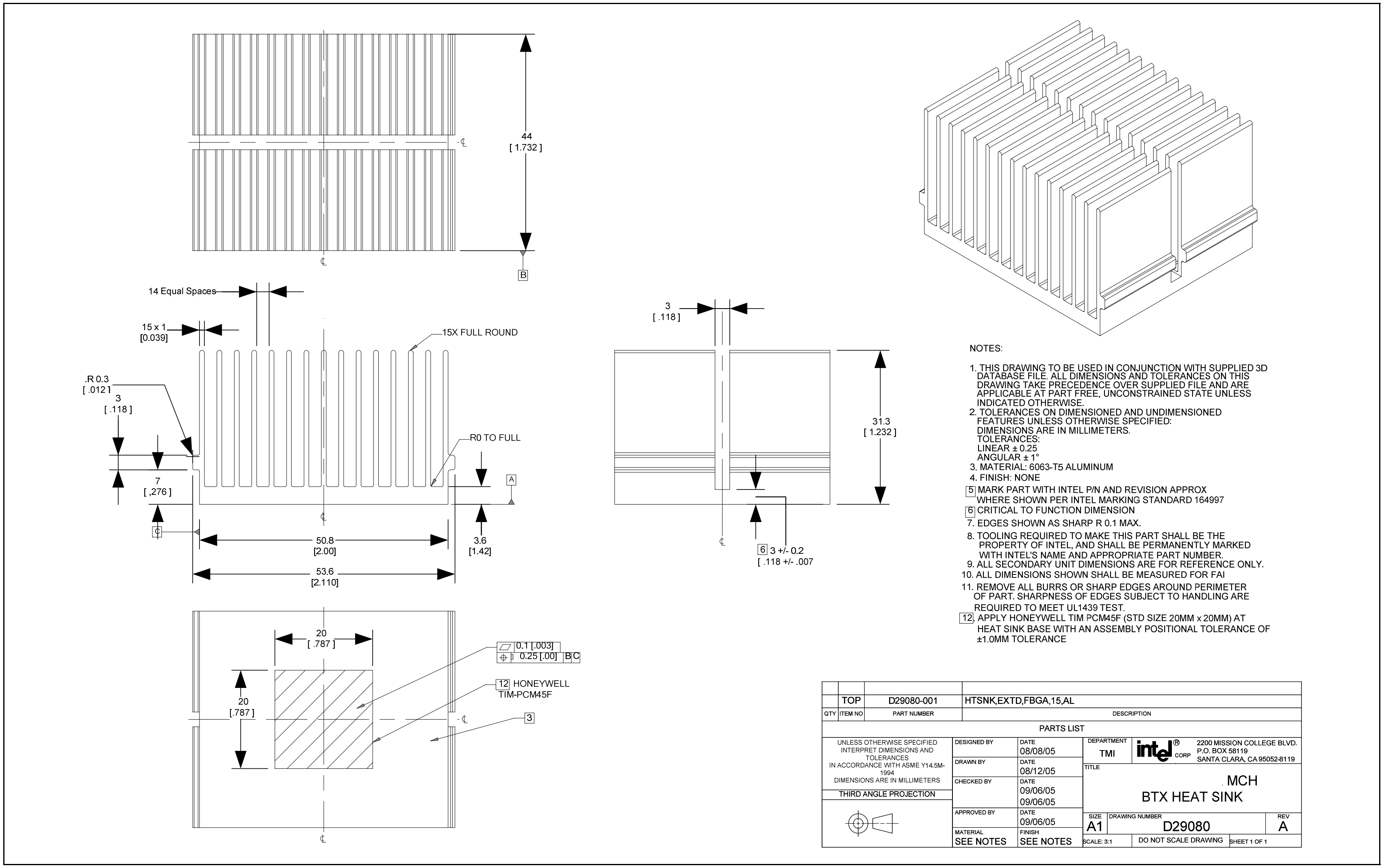


**Figure 48. MCH Reference Back Side Stiffener Plate for ATX Platforms – Flush Mount Stud**



## Figure 49. MCH Reference Heatsink for Balanced Technology Extended (BTX) Platforms



## Figure 50. MCH Reference Heatsink for Balanced Technology Extended (BTX) Platforms – Clip

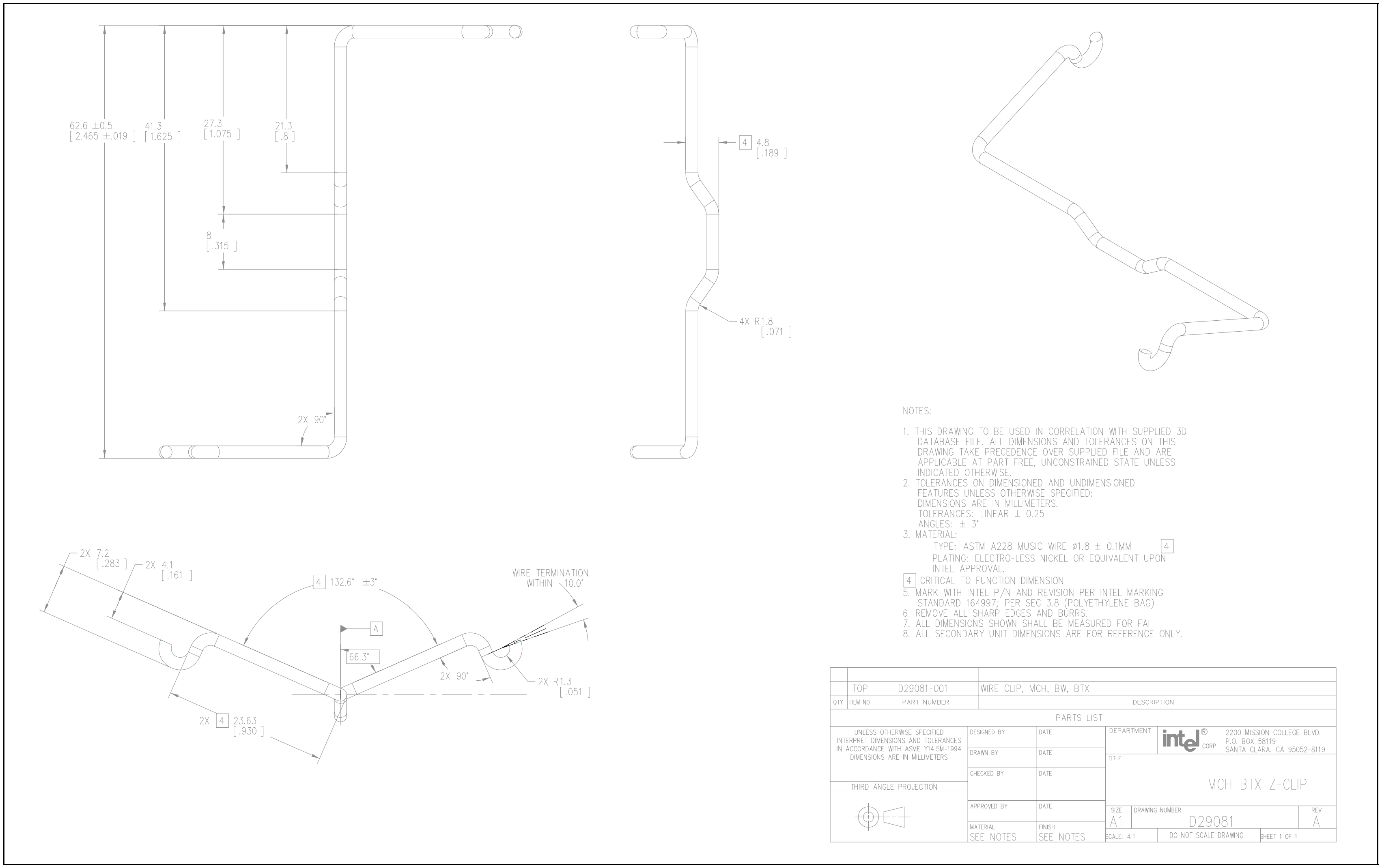


Figure 51. The Fixture Plate supporting IHS Groove on FCBGA7 Chipset Package on Live Board – Plate

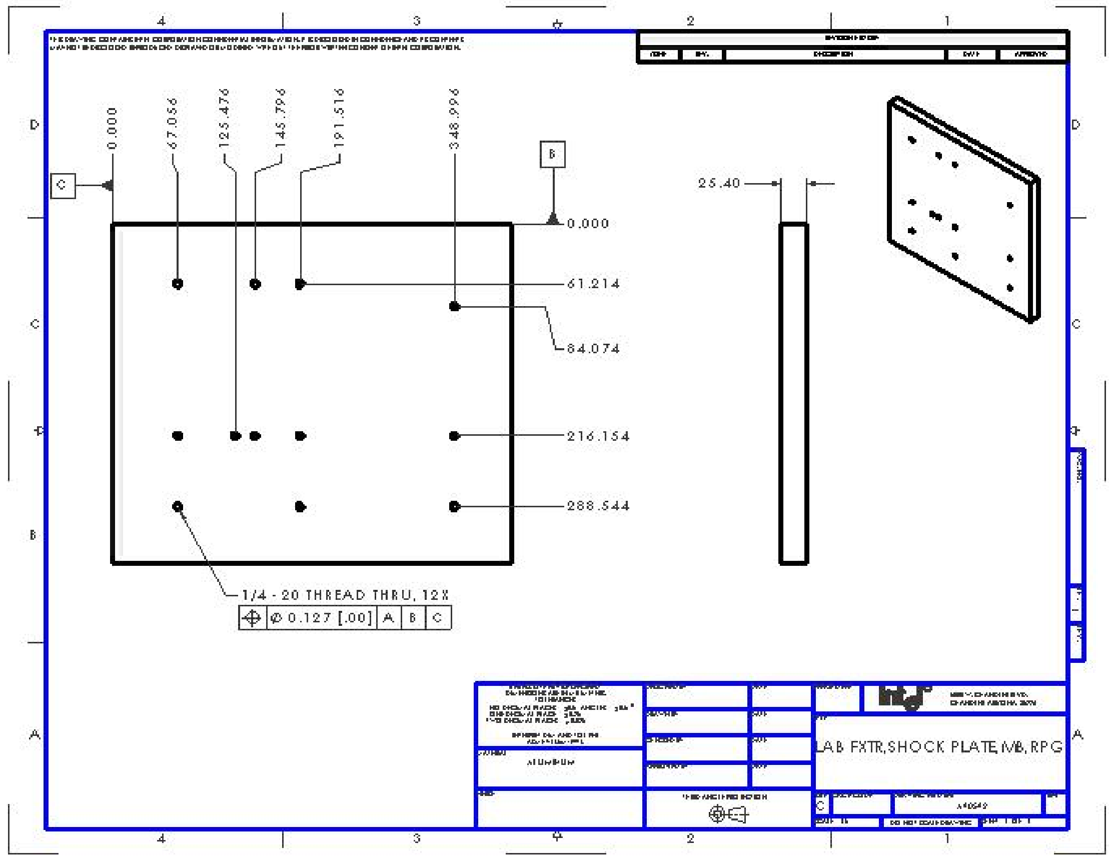
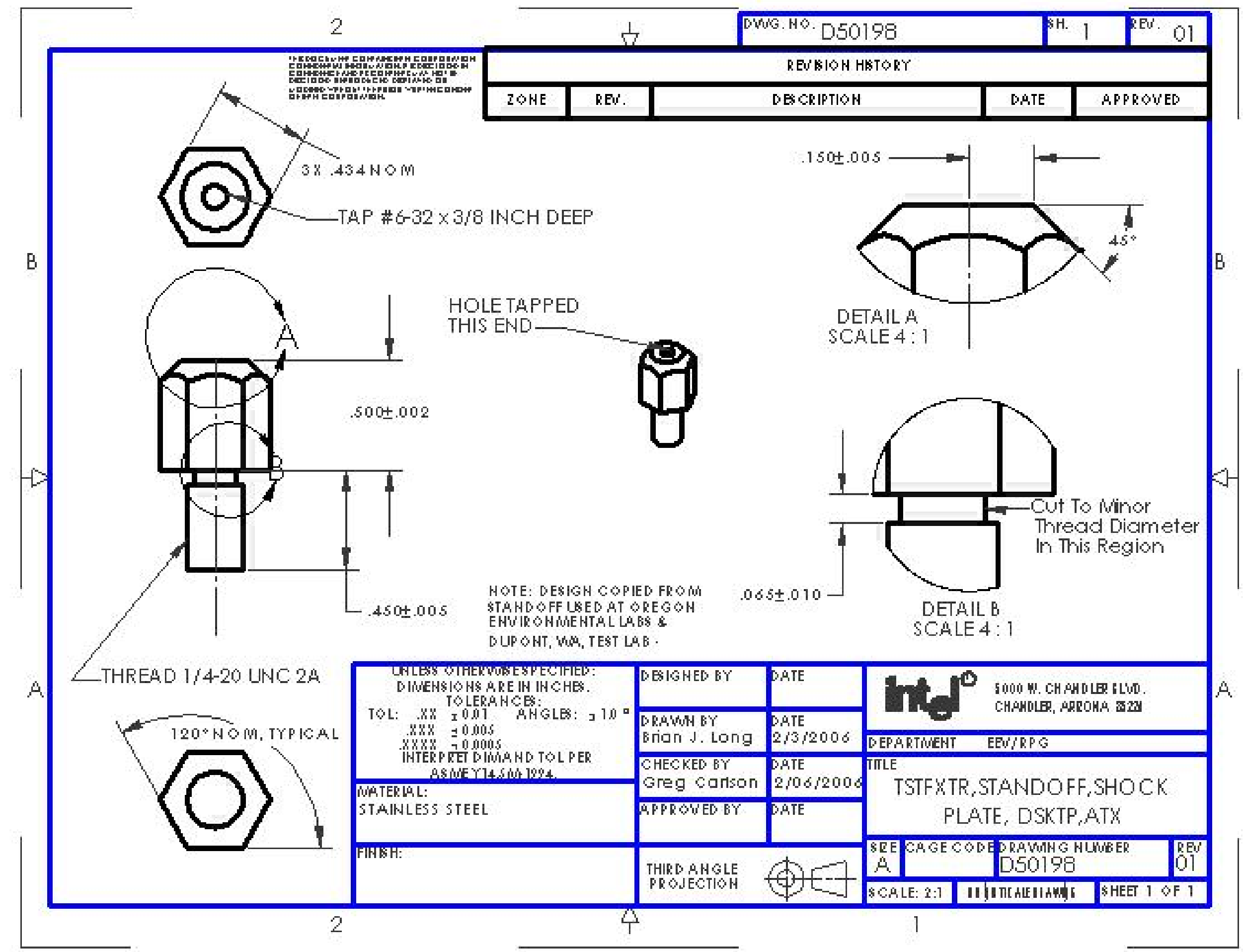


**Figure 52. The Fixture Plate supporting IHS Groove on FCBGA7 Chipset Package on Live Board – Standoff**

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